U.S. PATENT APPLICATION

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Invention: TRANSPARENT COLORING COMPOSITION AND COLOR FILTER

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SPECIFICATION

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TITLE OF THE INVENTION

TRANSPARENT COLORING COMPOSITION AND COLOR FILTER

BACKGROUND OF THE INVENTION:

The present invention relates to a transparent coloring composition and a color filter. More particularly, the present invention relates to a transparent coloring composition containing an organic-inorganic composite pigment exhibiting not only a sharp particle size distribution but also an excellent photofatigue resistance as well as excellent spectral properties, a photosensitive transparent coloring composition obtained from the coloring composition, and a color filter obtained from the transparent coloring composition or the photosensitive transparent coloring composition.

Pigments have been primarily used for hiding a color tone of a substrate material and for changing the color to that of the pigments by coating the surface of the substrate material therewith together with a vehicle. The hiding power of the pigments is exhibited as a sum of surface reflection of incident light, and absorption and scattering of the light by the pigments (refer to "Handbook for Technology of Color Materials" edited by Institute of Color Materials, published by Asakura Shoten (1989), p. 240). In addition, the hiding power is influenced by a size, a dispersion degree and a volume concentration of the pigment particles, a refractive index of the vehicle, etc. On the other hand, the pigments having excellent photofatigue resistance, heat resistance and

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chemical resistance, have also been used as transparent
colorants in extensive applications by further imparting a
transparency thereto in addition to these excellent properties.
One example of the applications is a color filter for liquid
crystal displays. With remarkable progress of liquid crystal
techniques, liquid crystal displays have been extensively used
in personal computers as well as portable telephones, digital
cameras, etc., and these liquid crystal displays are
increasingly shifted to full color types. The liquid crystal
devices are operated on the basis of such a principle that a
liquid crystal enclosed between a pair of transparent
electrodes is reversibly changed in orientation by applying an
electric field to the electrodes, thereby producing shading
due to change in transmittance of polarized light passed
therethrough. The full coloration of the liquid crystal
displays is achieved by providing regular pattern layers
composed of three primary colors including red, blue and green,
or cyan, yellow and magenta in respective fine regions on the
transparent electrodes. The thus obtained patterned optical
device constitutes a color filter, and have been required to
be further improved in optical properties such as color
properties, transmittance and contrast.

Also, a color filter for image pickup tubes is an optical
device that is inevitably required to digitize full color
images, and has been required to be considerably minimized in
order to reproduce full color images having a high definition
or resolution.

Typical examples of the method for production of a color

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filter for liquid crystal devices may include a pigment dispersion method, a dyeing method, a printing method, an electrodeposition method, etc. The dyeing method tends to be complicated in the production process and deteriorated in photofatigue resistance of the obtained product, and is, therefore, not frequently used. The printing method is still insufficient in accuracy irrespective of excellent productivity and low costs. The electrodeposition method has such a problem that the obtained product tends to be deteriorated in light transmittance due to formation of double ITO films required as transparent electrodes. On the other hand, the pigment dispersion method is simplified in production process and provides a color filter having an excellent photofatigue resistance, and, therefore, has been presently used as a main technique for production of the color filter (CMC, "2001 Markets of Constituting Materials for Liquid Crystal Displays", (2001), p. 115).

In order to produce a pigment dispersion-type color filter, there have been proposed methods of patterning a coating film made of a composition prepared by dispersing fine pigment particles having specific particle sizes in a photosensitive resin, by photolithography (Japanese Patent Application Laid-open (KOKAI) Nos. 60-129707(1985), 60-129739(1985), 9-197118(1997), 2001-214077 and 2002-328215).

In addition, there has been proposed a method of patterning a resin layer in which a soluble pigment precursor is dissolved in a molecular state, and then converting the soluble pigment precursor into an insoluble pigment by

deprotection reaction using a chemical, thermal or photolytic method to form a transparent colored pattern (Japanese Patent Application Laid-open (KOKAI) No. 8-6242(1996)).

As the photosensitive resin, there have been proposed water-soluble polymers substituted with photo-crosslinking group (Japanese Patent Publication (KOKOKU) No. 3-49422(1991)), radically photo-polymerizable resins composition (Japanese Patent Application Laid-open (KOKAI) Nos. 10-260310(1998) and 2000-47022), chemically amplified-type photoresists based on a catalytic reaction initiated by an acid produced from a photo-acid generator (Japanese Patent Application Laid-open (KOKAI) Nos. 7-84111(1995), 9-203806(1997), 10-260532(1998) and 10-39127(1998)), or the like.

Further, there have been proposed methods of subjecting an alkali-developable positive photoresist layer formed on an alkali-soluble resin layer in which fine pigment particles are dispersed, to exposure to light and to alkali development, and then etching and removing portions of the pigment-containing layer which are uncovered with the thus alkali-developed resist pattern (Japanese Patent Application Laid-open (KOKAI) Nos. 2000-53908 and 11-153706(1999)).

Meanwhile, the contrast of displays strongly depends upon depolarization of a color filter used therein. The depolarization further depends upon a scattering cross section of pigment contained in a pigment-dispersed film (Mure, Araizaki, Deguchi and Fujii, "SumitomoKagaku, 1998-II", p. 11). Since the scattering cross section is determined by a refractive index ratio between the pigment and binder resin,

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and a particle size of the pigment, the depolarization may be improved by reducing the particle size of the pigment and the scattering cross section. Therefore, optical properties of the color filter be improved by minimizing the particle size of the pigment particles contained in the colored film. However, even though a primary particle size of the pigment particles is sufficiently small, if the pigment particles are secondarily agglomerated, the pigment particles finally have a large particle size, thereby failing to improve the optical properties of the color filter. Namely, the small primary particle size is a necessary condition, but is not a sufficient condition.

On the other hand, in order to obtain an organic-inorganic composite pigment composed of inorganic pigment particles and an organic pigment adhered onto the surface thereof, there have been proposed techniques for synthesizing or precipitating the organic pigment in the presence of inorganic pigment, techniques for adhering the organic pigment onto the surface of inorganic pigment by a mechanically mixing and milling treatment, techniques for dissolving the organic pigment in a solvent, dispersing inorganic pigment in the obtained solution and adding a poor solvent for the organic pigment to the resultant dispersion, etc., (Japanese Patent Application Laid-open (KOKAI) Nos. 4-132770(1992), 7-310027(1995), 10-88032(1998), 11-181329(1999), 2002-356625 and 10-183021(1998)).

Also, in order to obtain a scratch-resistance color filter, there has been proposed a method of adding silica

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particles surface-treated with an organosilane containing hydrolyzable group(s) to a coloring composition for color filter (Japanese Patent Application Laid-open (KOKAI) No. 10-268124(1998)).

Color filters produced by the pigment dispersion method have been extensively used in applications such as mainly liquid crystal displays because of merits such as excellent photofatigue resistance and simplified production process. The color filters have been required to be further improved in spectral properties such as color reproducibility, transmittance and contrast. In addition, in order to obtain a color filter for image pickup tubes, it has been demanded to provide a coloring composition which is not adversely influenced by the particle size of pigment used therein even when the pigment is formed into ultrafine particles due to the increased number of pixel. To meet the above requirements, it has been required to provide a coloring composition and a color filter in which a pigment having a particle size as fine as possible and a narrow particle size distribution is dispersed.

In order to pulverize the pigment into fine particles, there has been most frequently used a mechanical pulverization method. For example, in Japanese Patent Application Laid-open (KOKAI) Nos. 60-129707(1985), 60-129739(1985) and 9-197118(1997), there are described color filters using a pigment having a specified particle size. However, since the pigment is mechanically pulverized into fine particles, the resultant pigment particles have a non-uniform particle shape

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and fails to show a narrow particle size distribution.

In addition, in Japanese Patent Application Laid-open (KOKAI) Nos. 2001-214077 and 2002-328215, there are described methods for forming a pigment into fine particles by pulverizing the pigment together with a milling medium such as common salt, and then removing the milling medium by water-washing. However, the obtained particles may fail to have uniform particle shape and particle size distribution.

Further, in the technique described in Japanese Patent Application Laid-open (KOKAI) No. 8-6242(1996), there can be produced fine pigment primary particles. However, in this method, a long heating time is required for formation of the pigment in a polymer solid film (refer to Ichimura, "Functional Materials", Vol. 23, No. 3, p. 25(2003)), and a color tone thereof may be unstable.

In Japanese Patent Application Laid-open (KOKAI) Nos. 4-132770(1992) and 7-310027(1995), there are described organic-inorganic composite pigments obtained by synthesizing and precipitating organic pigment by conducting azo-coupling reaction in the presence of inorganic pigment having a refractive index of not less than 2.0. However, these techniques aim at attaining a hiding effect by the pigment, but may fail to obtain an organic-inorganic composite pigment having a high transparency.

In Japanese Patent Application Laid-open (KOKAI) No. 10-88032(1998), there is described the technique for mechanically mixing and milling inorganic pigment and organic pigment while both are kept in a solid state. However, in the specified

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particle size range of the composite pigment composition,
although it is possible to hide the pigment, the obtained
composite pigment may fail to show a high transparency.

In Japanese Patent Application Laid-open (KOKAI) No. 11-
181329(1999), there is described the technique of dispersing
organic pigment in cyclic silicone in which a modified
silicone is dissolved, adding inorganic pigment to the
obtained dispersion, and evaporating and removing the cyclic
silicone from the dispersion. However, in the specified
particle size range of the inorganic particles which aims to
attain a hiding effect, although it is possible to hide the
inorganic pigment, the obtained composite pigment may fail to
show a high transparency.

In Japanese Patent Application Laid-open (KOKAI) No.
2002-356625, there is described the technique for producing
organic-inorganic composite particles by modifying the surface
of white inorganic particles with organic residue and then
adhering organic pigment onto the thus modified surface of the
white inorganic particles. However, in this KOKAI, there is
not described a coloring composition having a high
transparency such as those used for color filters.

In Japanese Patent Application Laid-open (KOKAI) No. 10-
183021(1998), there is described the transparent coloring
composition containing organic-inorganic composite pigment
treated with a silylating agent. However, there is no
description concerning the particle size required for ensuring
a transparency of the organic-inorganic composite pigment.

In Japanese Patent Application Laid-open (KOKAI) No. 10-

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268124(1998), there is described the technique of adding
silica particles surface-treated with an organosilane
containing hydrolyzable group(s) to a coloring composition for
color filter. However, since the coloring pigment and silica
particles are separately added to the coloring composition,
the pigment particles tends to be agglomerated, so that it may
be difficult to obtain a coloring composition for color filter
having a high transparency.

As a result of the present inventors' earnest studies for
solving the above problems, it has been found that when the
surface of fine white inorganic particles is treated with an
organic surface modifier and then the resultant surface-
treated fine white inorganic particles are mixed and milled
with an organic pigment, it is possible to obtain an organic-
inorganic composite pigment containing primary particles
having an average particle size of 1 to 100 nm and exhibiting
a high transparency. The present invention has been attained
on the basis of this finding.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a
coloring composition containing organic-inorganic composite
pigment having not only a sharp particle size distribution but
also exhibiting an excellent photofatigue resistance and
excellent spectral properties.

Another object of the present invention is to provide a
transparent coloring composition exhibiting an excellent
photosensitivity.

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A further object of the present invention is to provide a color filter exhibiting a light transmittance of not less than 75% in a transmission range of respective colors.

To accomplish the aims, in a first aspect of the present invention, there is provided a transparent coloring composition comprising an organic-inorganic composite pigment comprising fine white inorganic particles and an organic pigment adhered to the surface of the respective fine white inorganic particles, primary particles of the composite pigment having an average particle diameter of 1 to 100 nm; and a solvent.

In a second aspect of the present invention, there is provided a transparent coloring composition comprising an organic-inorganic composite pigment comprising fine white inorganic particles, a surface modifier coated on the surface of the respective fine white inorganic particles and an organic pigment adhered to the surface modifier coating layer, primary particles of the composite pigment having an average particle diameter of 1 to 100 nm; and a solvent.

In a third aspect of the present invention, there is provided a transparent coloring composition comprising the transparent coloring composition as defined in the above aspect 1 or 2, and a transparent resin having at least one acid group and/or latent acid group.

In a fourth aspect of the present invention, there is provided a photosensitive transparent coloring composition comprising the transparent coloring composition as defined in

the above aspect 3, a radical photo-initiator and a polyfunctional monomer having two or more ethylenically unsaturated double bonds.

In a fifth aspect of the present invention, there is provided a photosensitive transparent coloring composition comprising the transparent coloring composition as defined in the above aspect 3 and a photo-acid generator.

In a sixth aspect of the present invention, there is provided a color filter comprising a film-forming material composed of the transparent coloring composition as defined in any of the above aspects 3 to 5.

DETAILED DESCRIPTION OF THE INVENTION

The compound and composition constituting the coloring composition of the present invention are described in detail below.

<Organic-inorganic composite pigment>

Conventional colorants for pigment dispersion-type color filters are composed of finely pulverized organic pigment solely. On the other hand, the colorant of the present invention is essentially different from the conventional colorants in that the colorant of the present invention is composed of organic-inorganic composite pigment. The organic-inorganic composite pigment can be produced (1) by mechanically adhering the organic pigment onto the surface of the fine white inorganic particles, or (2) by surface-treating the surface of fine white inorganic particles so as to allow an organic pigment to be readily adhered thereonto and then

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mechanically adhering the organic pigment onto the surface of the surface-treated fine white inorganic particles.

Next, the fine white inorganic particles as core particles, the surface-treating agent, method, the organic pigment and the organic-inorganic composite pigment are explained in detail.

Examples of the fine white inorganic particles as core particles usable in the present invention may include silica, clay, calcium carbonate, barium sulfate, alumina, talc or the like. The primary particles of the fine white inorganic particles have an average particle diameter of usually 0.9 to 99 nm, preferably 0.9 to 89 nm, more preferably 0.9 to 79 nm. The fine white inorganic particles may be of any suitable shape such as spherical shape, granular shape, polyhedral shape, acicular shape, spindle shape, rice grain-like shape, flake shape, scale shape and plate shape. In particular, when spherical fine white inorganic particles are used as core particles, the resultant organic and inorganic pigment also has a spherical shape. The spherical shape is preferable since the contact surface between the pigment particles is restricted, and dispersion of the pigment in a solvent is facilitated. The particle diameter and shape of primary particles of the fine white inorganic particles may be determined by observation using a microscope.

The primary particles of the fine white inorganic particles used in the present invention have a geometrical standard deviation of particle size of usually not more than 2.0, preferably not more than 1.8, more preferably not more

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than 1.5. When the geometrical standard deviation is more
than 2.0, the resultant organic-inorganic composite pigment
tends to have a broad particle size distribution, so that a
color filter produced using such an organic-inorganic
composite pigment tends to show an increased degree of light
scattering, a reduced transmittance, and a deteriorated
contrast.

The fine white inorganic particles used in the present
invention have a BET specific surface area value of usually 10
to 1,000 m^2/g, preferably 15 to 750 m^2/g. When the BET
specific surface area value is less than 10 m^2/g, the white
inorganic particles tends to become coarse, so that the
resultant organic-inorganic composite pigment produced
therefrom also tends to be coarse particles, resulting in poor
transparency.

The fine white inorganic particles used in the present
invention preferably have such a refractive index that the
difference in refractive index between the fine white
inorganic particles and the organic pigment or transparent
resin is as small as possible in order to prevent occurrence
of light scattering and ensure a good transparency. Since the
refractive index of the organic pigment is generally in the
range of 1.2 to 2.5 and that of the transparent resin is
generally in the range of 1.4 to 1.7, the fine white inorganic
particles having a refractive index of usually 1.2 to 2.0,
preferably 1.3 to 1.8, more preferably 1.3 to 1.7, are used.
The transparency of the fine white inorganic particles can be
enhanced by inhibiting scattering of light thereon.

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When the behavior particle diameter of the fine white inorganic particles is expressed by a volume average particle diameter (Dp_{50}) thereof, the lower limit of the volume average particle diameter is usually more than 10.00 μm. In order to obtain such an organic-inorganic composite pigment having a volume average particle diameter (Dp_{50}) of not more than 5.00 μm, the volume average particle diameter (Dp_{50}) of the fine white inorganic particles are also preferably as low as possible. The upper limit of the volume average particle diameter (Dp_{50}) as the behavior particle diameter of the fine white inorganic particles is usually 100.00 μm, preferably 80.00 μm.

The behavior particles of the fine white inorganic particles used in the present invention have a volume maximum particle diameter (Dp_{99}) of usually not more than 200.00 μm, preferably not more than 190.00 μm, more preferably not more than 180.00 μm.

As to the hue of the fine white inorganic particles used in the present invention, the L* value thereof is usually not less than 70.00, preferably not less than 75.00; and the C* value thereof is usually not more than 18.00, preferably not more than 15.00, more preferably not more than 12.00. When the L* and C* values are out of the above-specified ranges, the color developing property of the organic pigment adhered onto the fine white inorganic particles tends to be unsuitably deteriorated.

As to the photofatigue resistance of the fine white inorganic particles used in the present invention, when

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measured by the below-mentioned method, the lower limit of the

ΔE^* value is usually more than 5.0, and the upper limit

thereof is usually 12.0, preferably 11.0, more preferably

10.0.

The surface of the fine white inorganic particles used in

the present invention is preferably coated with a surface

modifier in order to facilitate adhesion of the organic

pigment thereonto and ensure stable adhesion of the organic

pigment even in the presence of a solvent. Examples of the

surface-treating agent suitably used for this purpose may

include organosilicon compounds such as alkoxysilanes,

fluoroalkylsilanes, silane-based coupling agents and

organopolysiloxanes; coupling agents such as titanate-based

coupling agents, aluminate-based coupling agents and

zirconate-based coupling agents; low-molecular or high-

molecular surfactants; or the like.

Specific examples of the organosilicon compounds may

include alkoxysilanes such as methyltriethoxysilane,

dimethyldiethoxysilane, phenyltriethoxysilane,

diphenyldiethoxysilane, methyltriethoxysilane,

dimethyldimethoxysilane, phenyltrimethoxysilane,

diphenyldimethoxysilane, ethyltriethoxysilane,

propyltriethoxysilane, butyltriethoxysilane,

isobutyltrimethoxysilane, hexyltriethoxysilane,

octyltriethoxysilane and decyltriethoxysilane;

fluoroalkylsilanes such as trifluoropropyltrimethoxysilane,

tridecafluorooctyltrimethoxysilane,

heptadecafluorodecyltrimethoxysilane,

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trifluoropropyltriethoxysilane,

heptadecafluorodecyltriethoxysilane and

tridecafluorooctyltriethoxysilane; silane-based coupling

agents such as vinyltrimethoxysilane, vinyltriethoxysilane,

γ-aminopropyltriethoxysilane,

 γ-glycidoxypropyltriethoxysilane,

γ-mercaptopropyltrimethoxysilane,

γ-methacryloyloxypropyltrimethoxysilane,

N-(β-aminoethyl)-γ-aminopropyltrimethoxysilane,

γ-glycidoxypropylmethyldimethoxysilane and

γ-chloropropyltrimethoxysilane; organopolysiloxanes such as

polysiloxane, methylhydrogenpolysiloxane and modified

polysiloxanes; or the like.

Specific examples of the titanate-based coupling agents

may include isopropyltrisstearoyl titanate,

isopropyltris(dioctylpyrophosphate)titanate, isopropyltri(N-

aminoethyl-aminoethyl)titanate,

tetraoctylbis(ditridecylphosphate)titanate, tetra(2,2-

diallyloxymethyl-1-butyl)bis(ditridecyl)phosphate titanate,

bis(dioctylpyrophosphate)oxyacetate titanate,

bis(dioctylpyrophosphate)ethylene titanate or the like.

Specific examples of the aluminate-based coupling agents

may include acetoalkoxyaluminum diisopropylate, aluminum

diisopropoxymonoethylacetoacetate, aluminum

trisethylacetoacetate, aluminum trisacetylacetonate or the

like.

Specific examples of the zirconate-based coupling agents

may include zirconium tetrakisacetylacetonate, zirconium

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dibutoxybisacetylacetonate, zirconium

tetrakisethylacetoacetate, zirconium

tributoxymonoethykacetoacetate, zirconium

tributoxyacecylacetonate or the like.

Specific examples of the low-molecular surfactants may

include alkylbenzenesulfonic acid salts,

dioctylsulfonesuccinic acid salts, alkylamineacetic acid

salts, alkyl fatty acid salts or the like. Specific examples

of the high-molecular surfactants may include polyvinyl

alcohol, polyacrylic acid salts, carboxymethyl cellulose,

acrylic acid-maleic acid salt copolymer, olefin-maleic acid

salt copolymer or the like.

The surface modifier is coated in an amount of usually

0.01 to 15.0% by weight, preferably 0.02 to 12.5% by weight,

more preferably 0.03 to 10.0% by weight (calculated as C)

based on the weight of the fine white inorganic particles.

When the coating amount of the surface modifier is less than

0.01% by weight, it may be difficult to adhere not less than 1

part by weight of the organic pigment onto the 100 parts by

weight of the fine white inorganic particles. When the

coating amount of the surface modifier is not more than 15.0%

by weight, it is possible to adhere 1 to 500 parts by weight

of the organic pigment onto 100 parts by weight of the fine

white inorganic particles. Therefore, it is not required to

use the surface modifier in an amount of more than 15.0% by

weight.

As the organic pigment used in the present invention,

there may be used those organic pigments capable of exhibiting

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either (1) red, green and blue or (2) cyan, magenta and yellow.

Also, in order to improve spectral properties of the obtained

organic-inorganic composite pigment, these organic pigments

may be used in combination with other organic pigments having

different hues such as violet-based organic pigment exhibiting

a complementary color of blue.

Examples of the organic red-based pigments may include

quinacridone pigments such as quinacridon red, azo-based

pigments such as permanent red, condensed azo pigments such as

condensed azo red, vat dye-based pigments such as

dianthraquinonyl red and diketopyrrolopyrrole-based pigments,

perylene pigments such as perylene red, or the like. Examples

of the organic green-based pigments may include

phthalocyanine-based pigments such as phthalocyanine green, or

the like. Examples of the organic blue-based pigments may

include phthalocyanine-based pigments such as metal-free

phthalocyanine blue, phthalocyanine blue and fast sky blue,

alkali blue, or the like. Examples of the organic yellow-

based pigments may include monoazo-based pigments such as

Hanza yellow, disazo-based pigments such as benzidine yellow

and permanent yellow, condensed azo pigments such as condensed

azo yellow, isoindoline-based pigments such as isoindoline

yellow, or the like. Examples of the organic violet-based

pigments may include dioxazine-based pigments such as

dioxazine violet, or the like. The organic pigments usable in

the present invention are not particularly limited to the

above-exemplified pigments.

The amount of the organic pigment adhered is usually 1 to

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500 parts by weight, preferably 10 to 400 parts by weight,
more preferably 20 to 300 parts by weight based on 100 parts
by weight of the fine white inorganic particles. When the
amount of the organic pigment adhered is less than 1 part by
weight, since the amount of the fine white inorganic particles
having no tinting power is too large, the color concentration
of the resultant composite pigment tends to be insufficient.
On the other hand, when the amount of the organic pigment
adhered is more than 500 parts by weight, it may be difficult
to form a highly uniform adhesion layer of the organic
pigment.

The particle shape and particle size distribution of the
organic-inorganic composite pigment of the present invention
largely depend upon those of the fine white inorganic
particles as core particles, and have a particle configuration
similar to that of the fine white inorganic particles.

The primary particles of the organic-inorganic composite
pigment have an average particle diameter of usually 1 to 100
nm, preferably 1 to 90 nm, more preferably 1 to 80 nm. When
the average particle diameter of the primary particles is more
than 100 nm, the particle size thereof tends to be too large,
resulting in poor transparency. When the average particle
diameter of the primary particles is less than 1 nm, the
resultant pigment tends to be agglomerated due to too fine
particles, so that it may be difficult to uniformly disperse
the composite pigment in the transparent coloring composition.

The organic-inorganic composite pigment may have any
suitable particle shape such as spherical shape, granular

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shape, polyhedral shape, acicular shape, spindle shape, rice grain-like shape, flake shape, scale shape and plate shape. In particular, the organic-inorganic composite pigment particles preferably have a spherical shape because the contact surface between the pigment particles is restricted, and dispersion of the pigment in a solvent is facilitated.

The primary particles of the organic-inorganic composite pigment have a geometrical standard deviation of particle size of usually not more than 2.0, preferably not more than 1.8, more preferably not more than 1.5. When the geometrical standard deviation of the primary particles is more than 2.0, the primary particles of the organic-inorganic composite pigment have a too broad particle size distribution, so that a color filter produced using such an organic-inorganic composite pigment tends to show an increased degree of light scattering, a reduced transmittance, and a deteriorated contrast. In consideration of industrial productivity, the lower limit of the geometrical standard deviation of particle size of the primary particles of the organic-inorganic composite pigment is 1.01

The organic-inorganic composite pigment has a BET specific surface area value of usually 10 to 1,000 m^2/g, preferably 15 to 750 m^2/g. When the BET specific surface area value is less than 10 m^2/g, the organic-inorganic composite pigment tends to be coarse particles, resulting in poor transparency.

The volume average particle diameter (Dp_{50}) representing the behavior particle diameter of the organic-inorganic

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composite pigment is usually not more than 5.00 μm, preferably 0.01 to 4.50 μm, more preferably 0.01 to 4.00 μm. When the volume average particle diameter (Dp_{50}) of behavior particles of the organic-inorganic composite pigment is more than 5.00 μm, the color filter produced therefrom tends to be deteriorated in transmittance.

The behavior particles of the organic-inorganic composite pigment used in the present invention have a volume maximum particle diameter (Dp_{99}) of usually not more than 12.00 μm, preferably not more than 11.00 μm, more preferably not more than 10.00 μm. When the volume maximum particle diameter (Dp_{99}) of the organic-inorganic composite pigment is more than 12.00 μm, the existing coarse particles tend to inhibit a uniform film from being produced upon formation of a coating film of the color filter.

The organic-inorganic composite pigment has a tinting strength of usually not less than 110%, preferably not less than 115%, more preferably not less than 120%, when evaluated by the below-mentioned method.

As to the photofatigue resistance of the organic-inorganic composite pigment, the ΔE^* value thereof is usually not more than 5.0, preferably not more than 4.0, when evaluated by the below-mentioned method.

The desorption degree of the organic pigment from the organic-inorganic composite pigment is usually Rank 5 or 4, preferably Rank 5, when evaluated by the below-mentioned visual observation method. When the desorption degree of the organic pigment is Rank 3, 2 or 1, the desorbed organic

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pigment tends to prevent the organic-inorganic composite pigment from being uniformly dispersed in the transparent coloring composition, and the desorbed organic pigment itself tends to be self-agglomerated or undergo crystal growth. As a result, the color filter produced using such an organic-inorganic composite pigment tends to be deteriorated in contrast due to light scattering.

The transparent coloring composition according to the first and second aspects of the present invention contains the above organic-inorganic composite pigment and a solvent, and may further contain a dispersant, etc., if required.

<Solvent>

The solvent used in the present invention is not particularly restricted as long as the organic-inorganic composite pigment, the transparent resin, the polyfunctional monomer having two or more ethylenically unsaturated double bonds, the photopolymerization initiator and the photoacid generator can be dissolved or dispersed therein, and the solvent can be evaporated and removed from the composition after coating. Examples of the solvent may include water; aromatic hydrocarbons such as toluene and xylene; ketones such as methyl ethyl ketone and cyclohexanone; amides such as N,N-dimethylformamide, N,N-dimethylacetamide and N-methyl pyrrolidone; ether alcohols such as ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, diethylene glycol monomethyl ether, propylene glycol monomethyl ether and propylene glycol monoethyl ether; ether acetates such as ethylene glycol monomethyl ether acetate, ethylene glycol

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monoethyl ether acetate, propylene glycol monomethyl ether

acetate and propylene glycol monoethyl ether acetate; acetic

acid esters such as ethyl acetate, butyl acetate and isobutyl

acetate; lactic acid esters such as lactic acid methyl ester,

lactic acid ethyl ester and lactic acid propyl ester; cyclic

esters such as ethylene carbonate, propylene carbonate and γ-

butyrolactone; or the like. These solvents may be used singly

or in the form of a mixture of any two or more thereof.

In the present invention, the solvent may be used in an

amount of usually 5 to 90% by weight, preferably 10 to 80% by

weight based on the total weight of the organic-inorganic

composite pigment, the transparent resin, the polyfunctional

monomer and the photopolymerization initiator. When the

amount of the solvent used is less than 5% by weight, the

resultant composition tends to show a too high viscosity,

thereby failing to form a uniform film. When the amount of

the solvent used is more than 90% by weight, the thickness of

a coating film obtained therefrom tends to be too small, so

that it may be difficult to obtain a color filter having

sufficient color concentration and contrast.

<Dispersant>

As the dispersant, there may be used at least one

surfactant selected from the group consisting of anionic

surfactants such as ammonium laurylsulfate and polyoxyethylene

alkylethersulfuric acid ester; cationic surfactants such as

stearylamine acetate and lauryltrimethylammonium chloride;

amphoteric surfactants such as lauryldimethylamine oxide and

laurylcarboxymethylhydroxyethyl imidazolium betaine; nonionic

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surfactants such as polyoxyethylene lauryl ether, polyoxyethylene stearyl ether and sorbitan monostearate.

In particular, when water is used as the solvent, the anionic surfactants, nonionic surfactants, cationic surfactants, sodium naphthalenesulfonate-formalin condensate, acetylene glycol-based dispersants, etc., are preferably used as the dispersant.

The transparent coloring composition according to the first and second aspects of the present invention has a viscosity of usually 0.5 to 800 mPa·s. When the viscosity of the transparent coloring composition is more than 800 mPa·s, it may be difficult to obtain a uniform coating film thereof. When the viscosity of the transparent coloring composition is less than 0.5 mPa·s, the thickness of the resultant coating film tends to be too thin.

The dispersion average particle diameter (Dd_{50}) of the organic-inorganic composite pigment in the transparent coloring composition according to the first and second aspects of the present invention is usually not more than 300 nm, preferably not more than 250 nm, more preferably not more than 200 nm. The dispersion particle diameter (Dd_{84}) of the organic-inorganic composite pigment in the transparent coloring composition is usually not more than 600 nm, preferably not more than 550 nm, more preferably not more than 500 nm. The dispersion maximum particle diameter (Dd_{99}) of the organic-inorganic composite pigment in the transparent coloring composition is usually not more than 1,000 nm, preferably not more than 900 nm, more preferably not more than

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800 nm. The geometrical standard deviation (Dd_{84}/Dd_{50}) of the dispersion particle diameter (Dd_{84}) to the dispersion average particle diameter (Dd_{50}) is usually not more than 3.00, preferably not more than 2.75, more preferably not more than 2.50.

The transmittance values of the transparent coloring composition according to the first and second aspects of the present invention are as follows. The transparent coloring composition using the green-based organic-inorganic composite pigment exhibits a 530 nm transmittance of usually not less than 65%, preferably not less than 70%, more preferably not less than 75%; a 650 nm transmittance of usually not more than 5%, preferably not more than 3%; and a 650 nm specific absorptivity (based on weight) of usually 1.05 to 5.00, preferably 1.10 to 5.00, more preferably 1.20 to 5.00.

The transparent coloring composition using the blue-based organic-inorganic composite pigment exhibits a 460 nm transmittance of usually not less than 65%, preferably not less than 70%, more preferably not less than 75%; a 610 nm transmittance of usually not more than 5%, preferably not more than 3%; and a 610 nm specific absorptivity (based on weight) of usually 1.05 to 5.00, preferably 1.10 to 5.00, more preferably 1.20 to 5.00.

The transparent coloring composition using the red-based organic-inorganic composite pigment exhibits a 620 nm transmittance of usually not less than 65%, preferably not less than 70%, more preferably not less than 75%; a 550 nm transmittance of usually not more than 5%, preferably not more

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than 3%; and a 550 nm specific absorptivity (based on weight)
of usually 1.05 to 5.00, preferably 1.10 to 5.00, more
preferably 1.20 to 5.00.

The transparent coloring composition using the yellow-
based organic-inorganic composite pigment exhibits a 550 nm
transmittance of usually not less than 65%, preferably not
less than 70%, more preferably not less than 75%; a 400 nm
transmittance of usually not more than 5%, preferably not more
than 3%; and a 400 nm specific absorptivity (based on weight)
of usually 1.05 to 5.00, preferably 1.10 to 5.00, more
preferably 1.20 to 5.00.

The transparent coloring composition according to the
third aspect of the present invention is obtained by adding
the transparent resin to the transparent coloring composition
according to the first or second aspect of the present
invention.

<Transparent resin>

The transparent resin usable in the present invention is
not particularly restricted as long as the resin is soluble in
an alkali developing solution, has no absorption band in a
visible wavelength range, and exhibits a good film-forming
property. Examples of the transparent resin may include
polymers substituted with at least one acid group, or polymers
having at least one latent acid group capable of being
converted into an acid group by deprotection reaction due to
the effect of an acid. The acid group usable in the present
invention includes phenolic hydroxy and carboxyl. The amount
of the acid group introduced may be appropriately adjusted so

as to attain a good solubility of the transparent resin in an aqueous alkali solution.

Examples of the polymers having a phenolic hydroxy group may include novolak resins, homopolymers or copolymers of 4-hydroxystyrene, or the like.

Examples of the transparent resin having a carboxyl group may include vinyl-based copolymers of ethylenically unsaturated monomer with other copolymerizable unsaturated monomer. Examples of the monomer having a carboxyl group may include acrylic acid, methacrylic acid, 2-acryloyloxyethyl phthalate, 2-acryloyloxypropyl phthalate, maleic acid, maleic anhydride, itaconic acid, itaconic anhydride or the like. Examples of the other monomer copolymerizable with the monomer having a carboxyl group may include methyl (meth)acrylate, ethyl (meth)acrylate, propyl (meth)acrylate, butyl (meth)acrylate, cyclohexyl (meth)acrylate, isobornyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, benzyl (meth)acrylate, phenyl (meth)acrylate, 2-ethoxyethyl (meth)acrylate, 2-phenoxyethyl (meth)acrylate, 2-(N,N-dimethylamino)ethyl (meth)acrylate, glycidyl (meth)acrylate, (meth)acrylonitrile, (meth)acrylamide, (meth)acryloyl morpholide, N-methyl maleimide, N-phenyl maleimide, N-cyclohexyl maleimide, styrene, 4-vinyl toluene, vinyl acetate, vinyl methyl ether or the like.

The molar ratio of the carboxyl-containing monomer to the transparent resin is usually 0.005 to 0.5, preferably 0.05 to 0.4. When the molar ratio of the carboxyl-containing monomer is less than 0.005, the resultant copolymer tends to be

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deteriorated in solubility in the aqueous alkali solution,
resulting in occurrence of fogging upon patterning. When the
molar ratio of the carboxyl-containing monomer is more than
0.5, a coating film obtained from the resultant photosensitive
composition tends to be undesirably swelled at insolubilized
exposed portions thereof upon the alkali development after
exposure to light, resulting in deterioration in resolution as
well as surface smoothness of the obtained coating film. The
transparent resin has a weight-average molecular weight of
usually 2,000 to 500,000, preferably 3,000 to 300,000.

As the carboxyl-containing transparent resin, there may
be used polyamic acids obtained by polyaddition reaction of
tetracarboxylic dianhydride and diamine. Examples of the
tetracarboxylic dianhydride may include
1,2,3,4-cyclobutanetetracarboxylic dianhydride,
1,2,3,4-cyclopentanetetracarboxylic dianhydride,
1,2,3,5-cyclopentanetetracarboxylic dianhydride,
1,2,4,5-bicyclohexenetetracarboxylic dianhydride,
3,3',4,4'-benzophenonetetracarboxylic dianhydride,
pyromellitic dianhydride,
3,3',4,4'-diphenylsulfonetetracarboxylic dianhydride,
3,3',4,4'-biphenyltetracarboxylic dianhydride or the like, but
are not particularly limited thereto. Also, these
dianhydrides may be used singly or in the form of a mixture of
any two or more thereof. Examples of the diamines reacted
with these dianhydrides may include ethylenediamine,
1,3-diaminocyclohexane, 1,4-diaminocyclohexane,
4,4'-diaminodiphenyl ether, 3,4'-diaminodiphenyl ether,

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4,4'-diaminodiphenyl methane, 3,3'-diaminodiphenyl methane,
4,4'-diaminodiphenyl sulfone, 3,3'-diaminodiphenyl sulfone,
m-phenylenediamine, p-phenylenediamine, 2,4-diaminotolene,
2,5-diaminotolene or the like, but are not particularly
limited thereto.

The polyamic acids may be produced by reacting the
tetracarboxylic dianhydride with the diamine in a polar
organic solvent by known methods. The polymerization degree
of the polyamic acids may be controlled by changing the mixing
molar ratio between these components.

The latent acid group-containing transparent resin is a
polymer having a substituent group capable of producing a
carboxyl group or a phenolic hydroxy group by a catalytic
action of an acid generated from the photo-acid generator. As
such a transparent resin, there may be used base polymers used
in alkali-developable chemically amplified photoresists (refer
to C. P. Wong, "Polymers for Electronic and Photonic
Applications", Academic Press, p. 67(1993)). Examples of the
latent acid group-containing transparent resin may include
copolymers of cyclohexyl (meth)acrylate, tert-butyl
(meth)acrylate, tert-amyl (meth)acrylate, 1,1-dimethylbenzyl
(meth)acrylate, 1-ethoxyethyl (meth)acrylate, etc., with other
acrylate monomers containing (meth)acrylic acid, homopolymers
of 4-(tert-butoxycarbonyloxy)styrene, 4-(1-
methoxyethoxy)styrene, 4-(1-ethoxyethoxy)styrene, etc. or
copolymers of these monomers with 4-hydroxystyrene, or the
like.

These transparent resins substituted with an acid group

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and/or a latent acid group may be used in an amount of usually 5 to 500 parts by weight, preferably 7 to 300 parts by weight based on 100 parts by weight of the organic-inorganic composite pigment. When the amount of the transparent resin used is less than 5 parts by weight, the resultant composition tends to be deteriorated in film-forming property and alkali developability. When the amount of the transparent resin used is more than 500 parts by weight, since the concentration of the pigment is relatively lowered, the thickness of the coating film must be increased to ensure a color concentration required for the color filter. As a result, it may be difficult to obtain a film having a uniform thickness, and the resultant color filter tends to be deteriorated in optical properties.

The transparent coloring composition according to the third aspect of the present invention has a viscosity of usually 0.5 to 1,000 mPa·s. When the viscosity of the transparent coloring composition is more than 1,000 mPa·s, it may difficult to obtain a uniform coating film. When the viscosity of the transparent coloring composition is less than 0.5 mPa·s, the thickness of the obtained coating film tends to be too thin.

The dispersion average particle diameter (Dd_{50}) of the organic-inorganic composite pigment in the transparent coloring composition according to the third aspect of the present invention is usually not more than 300 nm, preferably not more than 250 nm, more preferably not more than 200 nm. The dispersion particle diameter (Dd_{84}) of the organic-

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inorganic composite pigment in the transparent coloring composition is usually not more than 600 nm, preferably not more than 550 nm, more preferably not more than 500 nm. The dispersion maximum particle diameter (Dd_{99}) of the organic-inorganic composite pigment in the transparent coloring composition is usually not more than 1,000 nm, preferably not more than 900 nm, more preferably not more than 800 nm. The geometrical standard deviation (Dd_{84}/Dd_{50}) of the dispersion particle diameter (Dd_{84}) to the dispersion average particle diameter (Dd_{50}) is usually not more than 3.00, preferably not more than 2.75, more preferably not more than 2.50.

The specific absorptivity values (based on weight) of the transparent coloring composition according to the third aspect of the present invention are as follows. The transparent coloring composition using the green-based organic-inorganic composite pigment exhibits a specific absorptivity at a wavelength of 650 nm of usually 1.05 to 5.00, preferably 1.10 to 5.00, more preferably 1.20 to 5.00. The transparent coloring composition using the blue-based organic-inorganic composite pigment exhibits a specific absorptivity at a wavelength of 610 nm of usually 1.05 to 5.00, preferably 1.10 to 5.00, more preferably 1.20 to 5.00. The transparent coloring composition using the red-based organic-inorganic composite pigment exhibits a specific absorptivity at a wavelength of 550 nm of usually 1.05 to 5.00, preferably 1.10 to 5.00, more preferably 1.20 to 5.00. The transparent coloring composition using the yellow-based organic-inorganic composite pigment exhibits a specific absorptivity at a

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wavelength of 400 nm of usually 1.05 to 5.00, preferably 1.10 to 5.00, more preferably 1.20 to 5.00.

Further, a colored transparent film obtained from the transparent coloring composition according to the third aspect of the present invention has a surface roughness Ra of usually not more than 20.0 nm, preferably not more than 15.0, more preferably not more than 10.0 nm; and a photofatigue resistance ΔE^* value of usually not more than 5.00, preferably not more than 4.50.

The transmittance values of the colored transparent film obtained from the transparent coloring composition according to the third aspect of the present invention are as follows. Namely, the colored transparent film using the green-based organic-inorganic composite pigment exhibits a 530 nm transmittance of usually not less than 75%, preferably not less than 80%, more preferably not less than 85%, still more preferably not less than 90%; and a 650 nm transmittance of usually not more than 5%, preferably not more than 3%.

The colored transparent film using the blue-based organic-inorganic composite pigment exhibits a 460 nm transmittance of usually not less than 75%, preferably not less than 80%, more preferably not less than 85%, still more preferably not less than 90%; and a 610 nm transmittance of usually not more than 5%, preferably not more than 3%.

The colored transparent film using the red-based organic-inorganic composite pigment exhibits a 620 nm transmittance of usually not less than 75%, preferably not less than 80%, more preferably not less than 85%, still more preferably not less

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than 90%; and a 550 nm transmittance of usually not more than
5%, preferably not more than 3%.

The colored transparent film using the yellow-based
organic-inorganic composite pigment exhibits a 550 nm
transmittance of usually not less than 75%, preferably not
less than 80%, more preferably not less than 85%, still more
preferably not less than 90%; and a 400 nm transmittance of
usually not more than 5%, preferably not more than 3%.

The transparent coloring composition according to the
fourth aspect of the present invention is obtained by adding a
photo-radial polymerization initiator and a polyfunctional
monomer having two or more ethylenically unsaturated double
bonds to the transparent coloring composition as defined in
the third aspect of the present invention.

In addition, the transparent coloring composition
according to the fifth aspect of the present invention is
obtained by adding a photo-acid generator to the transparent
coloring composition as defined in the third aspect of the
present invention.

<Polyfunctional monomer having two or more ethylenically
unsaturated double bonds>

As the method for producing the pigment dispersion-type
color filter, there have been proposed the etching method of
subjecting a pigment-free photosensitive film formed on a
pigment-containing coating film to exposure to light and then
to developing process in which patterns are formed on the
photosensitive layer and, at the same time, the pigment-
containing coating film is removed by etching; and the colored

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photosensitive material method in which a pigment is dispersed in a photosensitive layer itself ("Film-Forming Techniques and Chemicals for Color Filters" supervised by Watanabe, CMC Press (1998), p. 49). In the case where the color filter is produced from the coloring composition composed of the organic-inorganic composite pigment and the acid group-containing transparent resin, the former etching method is applicable thereto. In order to apply the latter colored photosensitive material method to such a composition, it is required to impart a photosensitivity to the coloring composition. The polyfunctional monomer having two or more ethylenically unsaturated double bonds is added to the transparent resin in order to impart a photosensitivity to the coloring composition and serves for initiating polymerization by radical species generated from the photopolymerization initiator at light-exposed portions thereof and inducing a crosslinking reaction to cause insolubilization of the composition.

Examples of the polyfunctional monomer having two or more ethylenically unsaturated double bonds may include polyfunctional monomers such as ethylene glycol di(meth)acrylate, diethylene glycol di(meth)acrylate, trimethylene glycol di(meth)acrylate, tetramethylene glycol di(meth)acrylate, pentamethylene glycol di(meth)acrylate, hexamethylene glycol di(meth)acrylate, neopentyl glycol di(meth)acrylate, pentaerythritol tri(meth)acrylate, pentaerythritol tetra(meth)acrylate, stearic acid-modified pentaerythritol (meth)acrylate, trimethylolpropane

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tri(meth)acrylate, tris(acryloyloxyethyl)isocyanurate ,
dipentaerythritol hexaacrylate and dipentaerythritol
pentaacrylate as well as acrylate oligomers obtained from
polyester resins, epoxy resins, urethane resins, silicone
resins, etc.

These polyfunctional monomers may be used in the form of
a mixture with monofunctional monomers. Examples of the
monofunctional monomers may include methoxytriethylene glycol
(meth)acrylate, 2-hydroxy-3-phenoxypropyl (meth)acrylate, 2-
acryloyloxyethyl succinate, 2-acryloyloxyethyl phthalate, 2-
acryloyloxypropyl phthalate or the like. These monofunctional
monomers may be used in an amount of usually 0 to 80 parts by
weight, preferably 0 to 40 parts by weight based on 100 parts
by weight of the polyfunctional monomer. When the amount of
the monofunctional monomers used exceeds the above-specified
range, the coating film obtained from the composition tends to
be partially peeled off or deteriorated in resolution upon the
alkali development after exposure to light.

The polyfunctional monomer used in the present invention
is preferably mixed in especially the carboxyl-containing
vinyl-based copolymer among the components of the transparent
resin. The amount of the polyfunctional monomer used is
usually 5 to 300 parts by weight, preferably 10 to 200 parts
by weight based on 100 parts by weight of the transparent
resin. When the amount of the polyfunctional monomer used is
less than 5 parts by weight, the coating film obtained from
the composition tends to be partially peeled off or
deteriorated in resolution after the alkali development. When

the amount of the polyfunctional monomer used is more than 300

parts by weight, the resultant composition tends to be

deteriorated in alkali developability, resulting in problems

such as fogging at unexposed portions of the coating film and

failed removal of the film.

<Photopolymerization initiator>

The photopolymerization initiator used in the present

invention is a substance capable of efficiently generating

radical species by irradiation of light, and serves for

initiating polymerization of the polyfunctional monomer to

form a crosslinked structure and reduce the alkali solubility

of the acid group-containing transparent resin, thereby

producing negative images. Examples of the

photopolymerization initiator may include ketone-based

compounds, triazine-based compounds containing a

trichloromethyl group, electron transfer-type initiators or

the like. Of these polymerization initiators, preferred are

such polymerization initiators capable of generating radical

species by irradiation of ultraviolet ray in a wavelength

range of 200 to 450 nm.

Specific examples of the ketone-based photopolymerization

initiators may include 2-hydroxy-2-methyl-1-phenylpropan-1-one,

1-hydroxy-1-benzoylcyclohexane, 2-morpholino-2-methyl-1-

phenylpropan-1-one, 2-morpholino-2-methyl-1-(4-

methoxyphenyl)propan-1-one, 2-morpholino-2-methyl-1-(4-

methylthiophenyl)propan-1-one, 2-benzyl-2-dimethylamino-1-(4-

morpholinophenyl)butan-1-one, 2-phenyl-2,2-dimethoxy-1-(4-

methylthiophenyl)ethan-1-one, diphenylmesitylenephosphine

oxide, phenacyltetramethylenesulfonium hexafluorophosphate or the like.

Specific examples of the triazine-based compounds containing a trichloromethyl group may include 2-(4-methoxy-β-styryl)-bis(4,6-trichloromethyl)-s-triazine, 1-phenyl-3,5-bis(trichloromethyl)-s-triazine, 1-(4-chlorophenyl)-3,5-bis(trichloromethyl)-s-triazine, 1-(4-methoxyphenyl)-3,5-bis(trichloromethyl)-s-triazine, 1-(4-butoxyphenyl)-3,5-bis(trichloromethyl)-s-triazine, 1-(3,4-methylenedioxyphenyl)-3,5-bis(trichloromethyl)-s-triazine, 1-(3,4-dimethoxyphenyl)-3,5-bis(trichloromethyl)-s-triazine, 1-(4-methoxynaphthyl-1)-3,5-bis(trichloromethyl)-s-triazine, 1-{2-(4-methoxyphenyl)ethenyl}-3,5-bis(trichloromethyl)-s-triazine, 1-{2-(2-methoxyphenyl)ethenyl}-3,5-bis(trichloromethyl)-s-triazine, 1-{2-(3,4-dimethoxyphenyl)ethenyl}-3,5-bis(trichloromethyl)-s-triazine, 1-{2-(3-chloro-4-methoxyphenyl)ethenyl}-3,5-bis(trichloromethyl)-s-triazine, 1- (biphenyl-1)-3,5-bis(trichloromethyl)-s-triazine or the like.

The electron transfer-type initiator is composed of a radical generator as an electron accepting compound or an electron donating compound, and a sensitizing agent. Examples of the electron accepting compound may include trichloromethyl-substituted triazine derivatives; biimidazole compounds such as 2,2'-bis(2-chlorophenyl)-4,4',5,5'-phenylbiimidazole, 2,2'-bis(2,4-dichlorophenyl)-4,4',5,5'-phenylbiimidazole and 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetrakis(4-ethoxycarbonylphenyl)biimidazole; iodonium salts

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such as diphenyliodonium hexafluorophosphate, bis(4-tert-

butylphenyl)iodonium hexafluorophosphate and

(4-methoxyphenyl)(4-octyloxyphenyl)iodonium

hexafluorophosphate; or the like. Examples of the sensitizing

agent may include 9,10-dimethyl anthracene, 9,10-diphenyl

anthracene, 9,10-bis(phenylethinyl)anthracene, 1,8-dimethyl-

9,10-bis(phenylethinyl)anthracene, 9,10-dimethoxyanthracene,

9,10-diethoxyanthracene, 9,10-dipropoxyanthracene,

9,10-dibutoxyanthracene, thioxanthone, isopropylthioxanthone,

4,4'-bis(diethylamino)benzophenone or the like. Further,

there may also be used photopolymerization initiators composed

of an electron donating compound and a sensitizing agent.

Examples of the suitable electron donating compound may

include p-dimethylaminobenzoic acid esters, diethanolamine or

the like. Examples of the suitable sensitizing agent may

include thioxanthone derivatives or the like. One or more

kinds of sensitizing agents may be used in combination with

the above electron accepting compound or electron donating

compound.

<Photo-acid generator>

Examples of the photo-acid generator usable in the

present invention may include compounds applied to chemically

amplified-type photoresists or photo-cationic polymerization

which have an absorption band in a wavelength range of 200 to

430 nm (refer to "Imaging Organic Materials" edited by Society

of Organic Electronics Materials, Bunshin Press (1993), pp.

187 to 192), onium cationic compounds, halogen-containing

compounds capable of generating a halogen acid, and sulfonated

compounds capable of generating sulfonic acid.

Examples of the onium salts may include BF_4^- salts, PF_6^-

salts, AsF_6^- salts, SbF_6^- salts, $CH_3SO_3^-$ salts, $CF_3SO_3^-$ salts,

perfluorobutanesulfonates, benzenesulfonates,

p-toluenesulfonates or $(C_6F_5)_4B^-$ salts of

p-phenylthiophenyldiphenylsulfonium,

phenacyltetramethylenesulfonium, phenacyldimethylsulfonium,

(2-naphthylcarbonylmethyl) tetramethylenesulfonium, phenyl(4-

methoxyphenyl)iodonium, phenyl{4-(tert-butyl)phenyl}iodonium,

(4-bis{4-(tert-butyl)phenyl}iodonium, bis(4-

dodecylphenyl)iodonium, etc.

Examples of the halogen-containing compounds capable of

generating a halogen acid may include 1-(3,4-dimethoxyphenyl)-

3,5-bis(trichloromethyl)-s-triazine, 1-(4-methoxynaphthyl-1)-

3,5-bis(trichloromethyl)-s-triazine, 1-{2-(4-

methoxyphenyl)ethenyl}-3,5-bis(trichloromethyl)-s-triazine, 1-

{2-(2-methoxyphenyl)ethenyl}-3,5-bis(trichloromethyl)-s-

triazine, 1-{2-(3,4-dimethoxyphenyl)ethenyl}-3,5-

bis(trichloromethyl)-s-triazine, 1-{2-(3-chloro-4-

methoxyphenyl)ethenyl}-3,5-bis(trichloromethyl)-s-triazine, 1-

(biphenyl-1)-3,5-bis(trichloromethyl)-s-triazine,

1-(4-hydroxybiphenyl-1)-3,5-bis(trichloromethyl)-s-triazine,

1-(4-methoxybiphenyl-1)-3,5-bis(trichloromethyl)-s-triazine or

the like.

Examples of the acid generator capable of generating a

sulfonic acid may include

N-trifluoromethanesulfonyloxydiphenylmaleimide,

N-p-toluenesulfonyloxysuccinimide,

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N-camphor-sulfonyloxysuccinimide,

N-trifluoromethanesulfonyloxysuccinimide,

N-perfluorobutanesulfonyloxyphthalimide,

N-p-toluenesulfonyloxy-1,8-naphthalenecarboximide,

N-camphor-sulfonyloxy-1,8-naphthalenecarboximide,

N-trifluoromethanesulfonyloxy-1,8-naphthalenecarboximide,

N-perfluorobutanesulfonyloxy-1,8-naphthalenecarboximide or the

like.

These photo-acid generators may be used singly or under

the co-existence of the following sensitizing agents.

Examples of the sensitizing agents may include 9-methyl

anthracene, 9,10-dimethyl anthracene,9,10-diphenyl anthracene,

9,10-dimethoxyanthracene, 9,10-diethoxyanthracene,

9,10-dipropoxyanthracene, 9,10-dibutoxyanthracene,

1-methylpyrene, thioxanthone derivatives or the like.

The amount of the photo-acid generator used is 0.1 to 30

parts by weight based on 100 parts by weight of the

transparent resin.

The transparent coloring composition according to the

fourth and fifth aspects of the present invention has a

viscosity of usually 0.5 to 1,000 mPa·s. When the viscosity

of the transparent coloring composition is more than 1,000

mPa·s, it may difficult to obtain a uniform coating film.

When the viscosity of the transparent coloring composition is

less than 0.5 mPa·s, the thickness of the obtained coating

film tends to be too thin.

The dispersion average particle diameter (Dd_{50}) of the

organic-inorganic composite pigment in the transparent

coloring composition according to the fourth and fifth aspects of the present invention is usually not more than 300 nm, preferably not more than 250 nm, more preferably not more than 200 nm. The dispersion particle diameter (Dd_{84}) of the organic-inorganic composite pigment in the transparent coloring composition is usually not more than 600 nm, preferably not more than 550 nm, more preferably not more than 500 nm. The dispersion maximum particle diameter (Dd_{99}) of the organic-inorganic composite pigment in the transparent coloring composition is usually not more than 1,000 nm, preferably not more than 900 nm, more preferably not more than 800 nm. The geometrical standard deviation (Dd_{84}/Dd_{50}) of the dispersion particle diameter (Dd_{84}) to the dispersion average particle diameter (Dd_{50}) is usually not more than 3.00, preferably not more than 2.75, more preferably not more than 2.50.

The specific absorptivity values (based on weight) of the transparent coloring composition according to the fourth and fifth aspects of the present invention are as follows. The transparent coloring composition using the green-based organic-inorganic composite pigment exhibits a specific absorptivity (based on weight) at a wavelength of 650 nm of usually 1.05 to 5.00, preferably 1.10 to 5.00, more preferably 1.20 to 5.00. The transparent coloring composition using the blue-based organic-inorganic composite pigment exhibits a specific absorptivity (based on weight) at a wavelength of 610 nm of usually 1.05 to 5.00, preferably 1.10 to 5.00, more preferably 1.20 to 5.00. The transparent coloring composition

using the red-based organic-inorganic composite pigment exhibits a specific absorptivity (based on weight) at a wavelength of 550 nm of usually 1.05 to 5.00, preferably 1.10 to 5.00, more preferably 1.20 to 5.00. The transparent coloring composition using the yellow-based organic-inorganic composite pigment exhibits a specific absorptivity (based on weight) at a wavelength of 400 nm of usually 1.05 to 5.00, preferably 1.10 to 5.00, more preferably 1.20 to 5.00.

Further, a colored transparent film obtained from the transparent coloring composition according to the fourth and fifth aspects of the present invention has a surface roughness Ra of usually not more than 20.0 nm, preferably not more than 15.0, more preferably not more than 10.0 nm; and a photofatigue resistance ΔE^* value of usually not more than 5.00, preferably not more than 4.50.

The transmittance values of the colored transparent film obtained from the transparent coloring composition according to the fourth and fifth aspects of the present invention are as follows. Namely, the colored transparent film using the green-based organic-inorganic composite pigment exhibits a 530 nm transmittance of usually not less than 75%, preferably not less than 80%, more preferably not less than 85%, still more preferably not less than 90%; and a 650 nm transmittance of usually not more than 5%, preferably not more than 3%.

The colored transparent film using the blue-based organic-inorganic composite pigment exhibits a 460 nm transmittance of usually not less than 75%, preferably not less than 80%, more preferably not less than 85%, still more

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preferably not less than 90%; and a 610 nm transmittance of

usually not more than 5%, preferably not more than 3%.

The colored transparent film using the red-based organic-

inorganic composite pigment exhibits a 620 nm transmittance of

usually not less than 75%, preferably not less than 80%, more

preferably not less than 85%, still more preferably not less

than 90%; and a 550 nm transmittance of usually not more than

5%, preferably not more than 3%.

The colored transparent film using the yellow-based

organic-inorganic composite pigment exhibits a 550 nm

transmittance of usually not less than 75%, preferably not

less than 80%, more preferably not less than 85%, still more

preferably not less than 90%; and a 400 nm transmittance of

usually not more than 5%, preferably not more than 3%.

The color filter of the present invention has a light

transmittance in each color transmission range of usually not

less than 75%, preferably not less than 80%, more preferably

not less than 85%; and a contrast of usually not less than 800,

preferably not less than 1,000, more preferably not less than

1,200.

Next, the process for producing the transparent coloring

composition is explained.

First, the process for producing the organic-inorganic

composite pigment composed of the fine while inorganic

particles and the organic pigment is explained below.

In the process for producing the organic-inorganic

composite pigment according to the present invention, (1) the

fine while inorganic particles are mixed with the organic

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pigment, or (2) the fine while inorganic particles and the surface modifier are mixed with each other to coat the surface of the respective fine while inorganic particles with the surface modifier and the surface modifier-coated fine while inorganic particles are mixed with the organic pigment, and then, the resultant particles are pulverized and classified.

If required, the surface of the fine while inorganic particles may be previously coated with at least one intermediate coating material selected from the group consisting of hydroxides of aluminum, oxides of aluminum, hydroxides of silicon and oxides of silicon. The coating with the intermediate coating material is conducted as follows. That is, an aluminum compound and/or a silicon compound are added to a water suspension prepared by dispersing the fine while inorganic particles in water. The resultant dispersion is mixed and stirred together and then, if required, the pH value thereof is adjusted adequately, thereby coating at least one intermediate coating material selected from the group consisting of hydroxides of aluminum, oxides of aluminum, hydroxides of silicon, and oxides of silicon, on the surface of the respective fine while inorganic particles. Thereafter, the thus-obtained fine while inorganic particles coated with the intermediate coating material are filtered out, washed with water, dried and then pulverized, and may be further subjected to subsequent treatments such as deaeration and compaction, if required.

Examples of the aluminum compound may include aluminum salts such as aluminum acetate, aluminum sulfate, aluminum

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chloride and aluminum nitrate, alkali aluminates such as sodium aluminate, or the like. Examples of the silicon compound may include water glass #3, sodium orthosilicate, sodium metasilicate or the like.

In order to promote the adhesion of the organic pigment, the fine while inorganic particles may be mechanically mixed and stirred with the surface modifier or a solution containing the surface modifier, or the fine while inorganic particles may be mechanically mixed and stirred while spraying the surface modifier or a solution containing the surface modifier to the fine while inorganic particles. The mixing and stirring may be preferably carried out using an apparatus capable of applying a shear force to the particles, especially such an apparatus capable of simultaneously effecting shear action, spatula stroking and compression. Examples of the apparatus may include wheel-type kneaders, ball-type kneaders, blade-type kneaders, roll-type kneaders or the like. Among these apparatuses, the wheel-type kneaders are preferred to effectively practice the present invention.

Specific examples of the wheel-type kneaders may include edge runners (similar in meaning to mix muller, Simpson mill and sand mill), multimill, Stotz mill, wet pan mill, corner mill, ring muller or the like. Among these wheel-type kneaders, the preferred kneaders are edge runners, multimill, Stotz mill, wet pan mill and ring muller, and the more preferred kneaders are edge runners. Specific examples of the ball-type kneaders may include vibration mill or the like. Specific examples of the blade-type kneaders may include

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Henschel mixer, planetary mixer, Nauter mixer or the like.
Specific examples of the roll-type kneaders may include
extruders or the like.

The conditions of the mixing and stirring treatment of
the fine white inorganic particles with the surface modifier
may be selected so as to uniformly coat the surface of the
fine white inorganic particles with the surface modifier.
Specifically, the mixing and stirring conditions may be
appropriately controlled such that the linear load is usually
19.6 to 1,960 N/cm (2 to 200 kg/cm), preferably 98 to 1,470
N/cm (10 to 150 kg/cm), more preferably 147 to 980 N/cm (15 to
100 kg/cm); the treating time is usually 5 minutes to 24 hours,
preferably 10 minutes to 20 hours; and the stirring speed is
usually 2 to 2,000 rpm, preferably 5 to 1,000 rpm, more
preferably 10 to 800 rpm.

After the surface of the fine white inorganic particles
is coated with the surface modifier, the organic pigment is
added, and then mixed and stirred with the surface modifier-
coated fine white inorganic particles to adhere the organic
pigment onto the surface modifier coating layer. The obtained
particles may be further subjected to drying and heating
treatments, if required. The organic pigment may be added
slowly and little by little especially for a period of 5
minutes to 24 hours, preferably 5 minutes to 20 hours.
Alternatively, usually 5 to 25 parts by weight of the organic
pigment may be dividedly added to 100 parts by weight of the
fine white inorganic particles until the amount of the organic
pigment added reaches the desired amount.

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The mixing and stirring conditions upon adhesion of the organic pigment may be appropriately selected so as to form a uniform organic pigment coat on the surface modifier coating layer, and may be controlled such that the linear load is usually 19.6 to 1,960 N/cm (2 to 200 kg/cm), preferably 98 to 1,470 N/cm (10 to 150 kg/cm), more preferably 147 to 980 N/cm (15 to 100 kg/cm); the treating time is usually 5 minutes to 24 hours, preferably 10 minutes to 20 hours; and the stirring speed is usually 2 to 2,000 rpm, preferably 5 to 1,000 rpm, more preferably 10 to 800 rpm.

As the apparatus for pulverizing the thus obtained organic-inorganic composite particles, there may be preferably used fine pulverizers or ultrafine pulverizers. Examples of the suitable pulverizers may include roller mills, impact pulverizers, ball mills, stirring mills, jet pulverizers or the like. Among these pulverizers, jet pulverizers and impact pulverizers can be used more effectively.

Examples of the jet pulverizers may include turning flow-type jet mills, fluidized bed-type jet mills or the like. Among these jet pulverizers, preferred are the fluidized bed-type jet mills. Examples of the impact pulverizers may include hammer mills, pin mills, screen mills, turbo-type mills, centrifugal classification-type mills or the like. Among these impact pulverizers, preferred are the pin mills. Examples of the roller mills may include ring roller mills, centrifugal roller mills or the like. Examples of the ball mills may include rolling ball mills, vibration ball mills, planetary mills or the like. Examples of the stirring mills

may include agitation tank-type mills, flowing tube-type mills, annular mills or the like.

As the apparatus for classifying the pulverized organic-inorganic composite particles, there may be suitably used dry-type classifiers such as, especially, gravity classifiers, inertia classifiers and centrifugal classifiers. Among these classifiers, the centrifugal classifiers can be used more effectively.

Specific examples of the centrifugal classifiers may include cyclone, classiclone, Startevant-type classifier, micron separator, turboplex, turbo classifier, super separator, dispersion separator or the like. Among these centrifugal classifiers, preferred are turboplex and micron separator. Examples of the gravity classifiers may include horizontal flow-type classifiers, vertical flow-type classifiers, slant flow-type classifiers or the like. Examples of the inertia classifiers may include linear-type classifiers, curve-type classifiers, slant-type classifiers or the like.

The conditions of the pulverization and classification may be appropriately selected so as to obtain the particles having the volume-average particle diameter and volume maximum particle diameter as aimed by the present invention.

The heating temperature used in the drying or heating treatment is usually 40 to 150°C, preferably 60 to 120°C, and the heating time is usually 10 minutes to 12 hours, preferably 30 minutes to 3 hours.

In order to produce the transparent coloring composition according to the first and second aspects of the present

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invention, the organic-inorganic composite pigment and the
dispersant are mixed and dispersed in a solvent. The mixing
and dispersing treatment may be conducted using a milling
apparatus such as ball mills, beads mills, sand mills, edge
runners, twin or triple roll mills, extruders, high-speed
impact mills, etc. The milling medium usable in the milling
apparatus may be selected from steel beads, glass beads,
ceramic beads, etc., according to material of the mill used,
and has a size of usually 0.01 to 10 mm, preferably 0.03 to 3
mm. The milling temperature is not particularly restricted,
and may be appropriately selected from the range of from room
temperature to a boiling point of the solvent.

In order to produce the transparent coloring composition
according to the third aspect of the present invention, the
transparent resin containing an acid group or a latent acid
group is dissolved in the transparent coloring composition
according to the first or second aspect of the present
invention. Alternatively, the organic-inorganic composite
pigment is mixed and dispersed in a solution previously
prepared by dissolving the transparent resin containing an
acid group or a latent acid group in a solvent.

In order to produce the photosensitive transparent
coloring composition according to the fourth aspect of the
present invention, the photopolymeization initiator and the
polyfunctional monomer having two or more ethylenically
unsaturated double bonds are added and mixed in the coloring
composition containing the transparent resin containing an
acid group according to the third aspect of the present

invention. In this case, a solvent may be added to the
composition, if required, to suitably adjust the pigment
concentration, viscosity, etc. Further, if required, a
polymerization inhibitor, a curing accelerator such as 2-
mercaptobenzoimidazole, etc., may be added to the composition.

In order to produce the photosensitive transparent
coloring composition according to the fifth aspect of the
present invention, a photo-acid generator is added and mixed
in the coloring composition containing the transparent resin
containing an acid group according to the third aspect of the
present invention.

Next, the process for producing the color filter using
the transparent coloring composition according to the present
invention is explained.

The transparent coloring composition of the present
invention is applied onto a transparent substrate on which
black matrix patterns are formed, and then pre-baked to fully
evaporate and remove the solvent therefrom, thereby obtaining
a colored coating film. In the case of the non-photosensitive
colored coating film, an alkali-developable positive
photoresist layer is formed on the film, thereby obtaining a
coating film with a two-layer structure. As the alkali-
developable positive photoresist, there may be suitably used
quinonediazide-based photoresist. The thus obtained colored
coating film is irradiated with light through a photo mask,
and then developed with an aqueous alkali solution. Since the
light-exposed portion of the positive photoresist-coated film
becomes alkali-soluble, the underlying colored layer exposed

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by the alkali development is also etched by the alkali solution, thereby obtaining a colored positive image. Then, the photoresist layer is selectively removed by a solvent to obtain a colored pattern. On the other hand, in the case of the photosensitive transparent coloring composition to which the photopolymerization initiator and the polyfunctional monomer are added, the prepared coating film is directly usable as a colored photosensitive layer. The coating film may be similarly exposed to light through a photo mask, and then alkali-developed to insolubilize the exposed portion, thereby obtaining a negative colored pattern. As the developing method, there may be used dipping method, spraying method, paddle method, shower method, etc. After the alkali development, the resultant film is washed with water and then dried.

As the transparent substrate for the color filter, there may be used such substrates made of silica glass as well as polycarbonates, polyesters, polyamides, polyimides, polyamide imides, etc. Also, in order to produce a solid image pickup device, there may be used a silicon substrate. The transparent coloring composition may be applied onto the transparent substrate by an appropriate method such as rotary coating, cast coating, roll coating and screen printing. The thickness of the coating film depends upon concentration of the organic-inorganic composite pigment, and is usually 0.1 to 10 μm, preferably 0.2 to 5.0 μm.

As the alkali developing solution, there may be used aqueous solutions of sodium carbonate, potassium carbonate,

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sodium hydroxide, potassium hydroxide,

tetramethylammoniumhydroxide or the like. The aqueous alkali

solution may also contain methanol, ethanol, isopropanol,

surfactants, etc.

The transparent coloring composition of the present

invention has the following advantages that are unobtainable

in case of using ordinary organic pigments as a coloring

material. First, the particle shape, particle diameter and

particle size distribution of the organic-inorganic composite

pigment according to the present invention are substantially

similar to those of the fine white inorganic particles as core

particles. The reason therefor is considered to be that the

organic pigment is uniformly adhered onto the surface of the

respective core particles or surface-treated core particles to

form a core/shell structure. For this reason, by

appropriately selecting the core particles, it is possible to

obtain fine pigment particles having a uniform shape, a very

small particle diameter and a narrow particle size

distribution. On the other hand, the conventional organic

pigments for color filters have been prepared by mechanical

pulverization or milling and, therefore, tend to exhibit an

uniform shape, so that it may be difficult to obtain particles

having a narrow particle size distribution. As a result, in

the color filter of the present invention, it is possible to

extremely minimize reflection and scattering of incident light,

and at the same time, the size of ultrafine colored patterns

of submicron order which are formed by photolithography is not

limited by the particle diameter of the pigment used.

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Secondary, the absorption coefficient of the organic
pigment component contained in the organic-inorganic composite
pigment of the present invention is increased as compared to
the case where the organic pigment is used solely. In
particular, when the volume-average particle diameter
(behavior particle diameter) of the composite pigment becomes
smaller, a hyper-chromic (color-concentrating) effect thereof
is more remarkably exhibited. The hyper-chromic phenomenon
has been first found by forming the organic pigment and
inorganic pigment into composite particles. The reason
therefor is considered to be that since the organic-inorganic
composite pigment particles of the present invention have a
core/shell structure, the incident light undergoes multiple
reflection on the boundary between the organic and inorganic
substances so that the absorption coefficient thereof is
apparently increased. Therefore, the organic-inorganic
composite pigment contained in the colored layer can exhibit
an increased color concentration even though the organic
pigment is used therein in the same amount as in the
conventional case where the organic pigment is used solely.
As a result, it becomes possible to produce a color filter
having an excellent color reproducibility.

The color filter obtained from the coloring composition
of the present invention has the above-mentioned advantages,
and, therefore, can be extremely usefully applied to color
liquid crystal displays, color image pickup devices, color
sensors, etc.

The organic-inorganic composite pigment contained in the

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transparent coloring composition exhibits a fine particle

diameter and a narrow particle size distribution as well as

excellent spectral properties due to high hyper-chromic effect

as compared to the case where the organic pigment is used

solely. Also, the transparent coloring composition containing

the organic-inorganic composite material is excellent in

dispersibility and spectral properties and, therefore,

suitably used for production of color filters. Further, the

color filter produced from the transparent coloring

composition has excellent spectral properties and, therefore,

can be suitably applied to color liquid crystal displays (LCD),

etc.

EXAMPLES

The present invention is described in more detail by

Examples and Comparative Examples, but the Examples are only

illustrative and, therefore, not intended to limit the scope

of the present invention.

Various properties were evaluated by the following

methods.

(1) The <u>average particle diameter of primary particles</u> of

the respective particles was expressed by an average value of

particle diameters of 350 particles observed on a micrograph.

(2) The <u>particle size distribution</u> of the primary

particles was expressed by the geometrical standard deviation

value obtained by the following method. That is, the particle

sizes were measured from the above magnified micrograph. The actual particle sizes and the number of the particles were obtained from the calculation on the basis of the measured values. On a logarithmic normal probability paper, the particle sizes were plotted at regular intervals on the abscissa-axis and the accumulative number of particles (under integration sieve) belonging to each interval of the particle sizes were plotted by percentage on the ordinate-axis by a statistical technique. The particle sizes corresponding to the number of particles of 50% and 84.13%, respectively, were read from the graph, and the geometrical standard deviation was obtained from the following formula:

Geometrical standard deviation =

{particle size corresponding to 84.13% under integration sieve}/{particle size (geometrical average diameter) corresponding to 50% under integration sieve}.

The more the geometrical standard deviation is close to 1, the more excellent the particle size distribution of the primary particles.

(3) The specific surface area was expressed by the value measured by a BET method.

(4) The amounts of Al and Si which were present on the surface of the fine white inorganic particle coated with the intermediate coating material, were respectively measured by a fluorescent X-ray spectroscopy device "3063 M-type" (manufactured by RIGAKU DENKI KOGYO CO., LTD.) according to JIS K0119 "General rule of fluorescent X-ray analysis".

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(5) The volume average particle diameter (Dp_{50}) and the volume maximum particle diameter (Dp_{99}) representing the conditions of behavior particles of the fine white inorganic particles and organic-inorganic composite pigment were measured as follows. That is, the sample particles were previously passed through a 60 mesh sieve (opening size: 250 μm), and then dried at 80°C for 3 hours using a drier. Thereafter, the respective parameters (Dp_{50}) and (Dp_{99}) of the sample particles were measured under a dispersion pressure of 0.1 MPa (1 bar) using a dry dispersion unit including a laser diffraction-type particle size distribution measuring device "Model HELOS LA/KA" (manufactured by Sympatec Co., Ltd.). Meanwhile, the behavior particles mean secondary particles formed by agglomeration of the primary particles.

(6) The amount of the surface modifier coating layer formed on the surface of the fine white inorganic particle, and the amount of the adhered organic pigment contained in the organic-inorganic composite pigment, were respectively determined by measuring the carbon contents using "Horiba Metal, Carbon and Sulfur Analyzer EMIA-2200 Model" (manufactured by Horiba Seisakusho Co., Ltd.).

(7) The degree of desorption of the organic pigment from the organic-inorganic composite pigment was visually observed and evaluated by the following method, and the observation results were classified into the following five ranks. The Rank 5 represents that the amount of the organic pigment desorbed from the surface of the organic-inorganic composite

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pigment was smallest.

That is, 2 g of the particles to be measured and 20 ml of ethanol were placed in a 50-ml conical flask and then subjected to ultrasonic dispersion for 60 minutes. Thereafter, the obtained dispersion was centrifuged at a rotating speed of 10,000 rpm for 15 minutes to separate the particles from the solvent. The obtained particles were dried at 80°C for one hour, and the micrograph (x 50,000) thereof was visually observed to count the number of the desorbed and re-aggregated organic pigment particles present in a visual field of the micrograph. The micrograph was compared with a micrograph (x 50,000) of a physical mixture obtained by simply mixing the fine white inorganic particles with the organic pigment. The results are classified into the following five ranks.

Rank 1: Number of desorbed and re-aggregated particles was substantially the same as that in the physical mixture;

Rank 2: 30 to 49 desorbed and re-aggregated particles per 100 particles of the organic and inorganic composite pigment;

Rank 3: 10 to 29 desorbed and re-aggregated particles per 100 particles of the organic and inorganic composite pigment;

Rank 4: 5 to 9 desorbed and re-aggregated particles per 100 particles of the organic and inorganic composite pigment; and

Rank 5: 0 to 4 desorbed and re-aggregated particles per 100 particles of the organic and inorganic

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composite pigment.

(8) The <u>hues</u> of the fine white inorganic particles, organic pigment, and organic-inorganic composite pigment, were measured by the following method.

That is, 0.5 g of each sample and 0.5 ml of castor oil were intimately kneaded together by a Hoover's muller to form a paste. 4.5 g of clear lacquer was added to the obtained paste and was intimately kneaded to form a paint. The obtained paint was applied onto a clear base film by using a 150 μm (6 mil) applicator to produce a coating film piece (having a coating film thickness of about 30 μm). The thus obtained coating film piece was placed on a standard white back plate and measured by a spectrophotometric colorimeter "CM-3610d" (manufactured by MINOLTA CO., LTD.) to determine color specification values thereof according to JIS Z 8929. Meanwhile, the C* value representing chroma is calculated according to the following formula:

$$C* = ((a*)^2 + (b*)^2)^{1/2}$$

(9) The <u>tinting strength</u> of the organic-inorganic composite pigment was measured by the following method.

That is, a primary color enamel and a vehicle enamel prepared by the below-mentioned methods were respectively applied on a clear base film by using a 150 μm (6 mil) applicator to produce coating film pieces. The thus obtained coating film pieces were placed on a standard white back plate, and the L* values thereof were measured by a spectrophotometric colorimeter "CM-3610d" (manufactured by

MINOLTA CO., LTD.). The difference between the obtained L*
values was represented by a ΔL* value.

Next, a control sample for the organic-inorganic
composite pigment was prepared by simply mixing the organic
pigment with the fine white inorganic particles at the same
mixing ratio as used upon the production of the organic-
inorganic composite pigment. Using the thus prepared mixed
particles as a control sample, the same procedure as defined
above was conducted to prepare an primary color enamel and a
vehicle enamel, form respective coating film pieces and then
measure L* values thereof. The difference between the L*
values was represented by a ΔLs* value.

From the obtained ΔL* value of the organic-inorganic
composite pigment and ΔLs* value of the control sample, the
tinting strength (%) was calculated according to the following
formula:

Tinting strength (%) = 100 + {(ΔLs* - ΔL*) x 10}

Preparation of primary color enamel:

10 g of the above sample particles, 16 g of an amino
alkyd resin and 6 g of a thinner were blended with each other.
The resultant mixture was added together with 90 g of 3mmφ
glass beads into a 140-ml glass bottle, and then mixed and
dispersed for 45 minutes by a paint shaker. The obtained
mixture was mixed with 50 g of an additional amino alkyd resin,
and further dispersed for 5 minutes by a paint shaker, thereby
obtaining a primary color enamel.

Preparation of vehicle enamel:

12 g of the above-prepared primary color enamel and 40 g

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of Amirac White (titanium dioxide-dispersed amino alkyd resin)
were blended with each other, and the resultant mixture was
mixed and dispersed for 15 minutes by a paint shaker, thereby
preparing a vehicle enamel.

(10) The photofatigue resistances of the fine white
inorganic particles, organic pigment, and organic-inorganic
composite pigment were measured by the following method.

That is, the primary color enamel prepared above for
measuring the tinting strength was applied onto a glass plate
(0.8 mm × 70 mm × 150 mm) and dried to form a coating film
having a thickness of 150 μm. One half of the thus prepared
coating film piece was covered with a metal foil, and an
ultraviolet light was continuously irradiated over the coating
film piece at an intensity of 100 mW/cm^2 for 6 hours using
"EYE SUPER UV TESTER SUV-W13" (manufactured by IWASAKI DENKI
CO., LTD.). Then, the hue values (L*, a* and b* values) of
the metal foil-covered UV-unirradiated portion and the UV-
irradiated portion of the coating film piece were respectively
measured. On the basis of the measured value of the UV-
unirradiated portion as a standard value, the ΔE* value was
calculated from differences between the measured hue values of
the metal foil-covered UV-unirradiated portion and the UV-
irradiated portion according to the following formula:

ΔE* = [(ΔL*)^2 + (Δa*)^2 + (Δb*)^2]$^{1/2}$

wherein ΔL* represents the difference between L* values of the
UV-unirradiated and UV-irradiated portions; Δa* represents the
difference between a* values of the UV-unirradiated and UV-

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irradiated portions; and Δb* represents the difference between

b* values of the UV-unirradiated and UV-irradiated portions.

(11) The <u>viscosity</u> of the transparent coloring

composition was expressed by the value obtained by measuring

the viscosity of the resultant composition at 25°C and a shear

rate (D) of 1.92 sec^{-1} using "E-type Viscometer EMD-R"

(manufactured by Tokyo Keiki Co., Ltd.).

(12) The <u>dispersion average particle diameter</u> (Dd_{50}), the

<u>dispersion particle diameter</u> (Dd_{84}) and the <u>dispersion maximum</u>

<u>particle diameter</u> (Dd_{99}) of the organic-inorganic composite

pigment contained in the transparent coloring composition were

measured by a dynamic light scattering method using a

concentrated particle size analyzer "FPAR-1000" (manufactured

by Otsuka Denshi Co., Ltd.). Meanwhile, the geometrical

standard deviation (Dd_{84}/Dd_{50}) was expressed by the value

calculated according to the following formula:

Geometrical standard deviation (Dd_{84}/Dd_{50}) =

{particle size (Dd_{84}) corresponding to 84.13% under

integration sieve}/{particle size (Dd_{50}) corresponding to 50%

under integration sieve}

The more the geometrical standard deviation value

(Dd_{84}/Dd_{50}) is close to 1, the more excellent the particle size

distribution of the behavior particles in the transparent

coloring composition.

(13) The <u>specific absorptivity values</u> of the respective

transparent coloring compositions were measured as follows.

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That is, the respective transparent coloring compositions were
diluted 1,000 times with propylene glycol monomethyl ether
acetate (PGMA). Using the thus prepared diluted solutions,
the absorptivity coefficient at a wavelength of 550 nm in the
case of the red-based coloring composition, the absorptivity
coefficient at a wavelength of 650 nm in the case of the
green-based coloring composition, the absorptivity coefficient
at a wavelength of 650 nm in the case of the blue-based
coloring composition and the absorptivity coefficient at a
wavelength of 400 nm in the case of the yellow-based coloring
composition were respectively measured using a self-recording
photoelectric spectrophotometer "UV-2100" (manufactured by
SHIMADZU SEISAKUSHO CO., LTD.). The specific absorptivity of
the respective transparent coloring compositions was expressed
by the value calculated according to the following formula:

$$\varepsilon_w = \varepsilon_h / \varepsilon_0$$

wherein ε_w represents a specific absorptivity; ε_h represents an
absorptivity coefficient per unit weight of the organic
pigment contained in each organic-inorganic composite pigment;
and ε_0 represents an absorptivity coefficient per unit weight
of the organic pigment used as a raw material of each organic-
inorganic composite pigment.

The larger the specific absorptivity value, the higher
the tinting effect of the organic pigment coated on the fine
white inorganic particles.

(14) The light transmittances of the transparent coloring
compositions according to the first and second aspects of the

present invention were measured as follows. That is, the
respective transparent coloring compositions were diluted such
that a concentration of the organic pigment contained therein
was 0.0078% by weight, and then filled in a quartz cell.
Using the thus prepared diluted solutions each filled in the
quartz cell, the light transmittances at wavelengths of 620 nm
and 550 nm in the case of the red-based transparent coloring
composition, the light transmittances at wavelengths of 530 nm
and 650 nm in the case of the green-based transparent coloring
composition, the light transmittances at wavelengths of 460 nm
and 610 nm in the case of the blue-based transparent coloring
composition, and the light transmittances at wavelengths of
550 nm and 460 nm in the case of the yellow-based transparent
coloring composition, were respectively measured using a self-
recording photoelectric spectrophotometer "UV-2100"
(manufactured by SHIMADZU SEISAKUSHO CO., LTD.).

(15) The surface roughness Ra of the colored transparent
film obtained from the respective transparent coloring
compositions was determined by measuring a center line average
roughness of the colored transparent film using a surface
roughness tester "Surfcom-575A" (manufactured by Tokyo
Seimitsu Co., Ltd.).

(16) The chromaticity of the colored transparent film
obtained from the respective transparent coloring compositions
was measured as follows. That is, the respective transparent
coloring compositions prepared by the below-mentioned methods
were applied onto a clear base film to form a coating film

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having a thickness of 150 μm, and then dried to obtain a

coating film piece having a colored transparent film. The

chromaticity of the thus obtained coating film piece was

measured using a spectrophotometric colorimeter "CM-3610d"

(manufactured by MINOLTA CO., LTD.), and expressed according

to XY chromaticity diagram prescribed by CIE (Commission

Internationale de I'Eclairage).

(17) The <u>photofatigue resistance</u> of the colored

transparent film obtained from the respective transparent

coloring compositions was measured by the following method.

That is, the respective transparent coloring compositions

were applied onto a glass plate (0.8 mm × 70 mm × 150 mm) to

form a coating film having a thickness of 150 μm and then

dried, thereby obtaining a coating film piece. A part of the

thus prepared coating film piece was covered with a metal foil,

and an ultraviolet light was continuously irradiated over the

coating film piece at an intensity of 100 mW/cm^2 for 6 hours

using "EYE SUPER UV TESTER SUV-W13" (manufactured by IWASAKI

DENKI CO., LTD.). Then, the hue values (L*, a* and b* values)

of the metal foil-covered UV-unirradiated portion and the UV-

irradiated portion of the coating film piece were respectively

measured using a spectrophotometric colorimeter "CM-3610d"

(manufactured by MINOLTA CO., LTD.). On the basis of the

measured value of the UV-unirradiated portion as a standard

value, the ΔE* value was calculated from differences between

the measured hue values of the metal foil-covered UV-

unirradiated portion and the UV-irradiated portion according

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to the formula described in the above (10).

(18) The <u>light transmittance</u> of the colored transparent
film obtained from the respective transparent coloring
compositions was measured as follows. That is, using the
coating film piece prepared above for measuring the
chromaticity, the light transmittances at wavelengths of 620
nm and 480 nm in the case of the red-based colored transparent
film, the light transmittances at wavelengths of 530 nm and
650 nm in the case of the green-based colored transparent film,
and the light transmittances at wavelengths of 460 nm and 630
nm in the case of the blue-based colored film, were
respectively measured using a self-recording photoelectric
spectrophotometer "UV-2100" (manufactured by SHIMADZU
SEISAKUSHO CO., LTD.).

(19) The <u>light transmittance</u> of the color filter was
determined using a color filter prepared by the below-
mentioned method. Specifically, the light transmittances at
wavelengths of 620 nm, 530 nm and 460 nm, were respectively
measured using a self-recording photoelectric
spectrophotometer "UV-2100" (manufactured by SHIMADZU
SEISAKUSHO CO., LTD.).

(20) The <u>contrast</u> of the color filter was measured as
follows. That is, the color filter prepared by the below-
mentioned method was interposed between two polarizing plates
on a back light, and the brightness (A) when arranging the two
polarizing plates in parallel with each other and the
brightness (B) when arranging the two polarizing plates

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perpendicularly to each other were respectively measured. The

contrast was expressed by a ratio of (A) to (B) ((A)/(B)).

Example 1:

<Production of organic-inorganic composite pigment (G)>

560 g of methylhydrogenpolysiloxane (tradename: "TSF484",

produced by GE TOSHIBA SILICONE CO., LTD.) was added to 7.0 kg

of silica particles (particle shape: spherical shape; average

particle diameter of primary particles: 17 nm; BET specific

surface area value: 211.3 m^2/g; geometrical standard deviation

value of primary particles: 1.27; volume average particle

diameter (Dp_{50}): 1.66 μm; volume maximum particle diameter

(Dp_{99}): 2.61 μm; refractive index: 1.42; L* value: 93.39; a*

value: 0.12; b* value: 0.26; C* value: 0.28; photofatigue

resistance: 5.48) while operating an edge runner, and the

resultant mixture was mixed and stirred for 30 minutes under a

linear load of 588 N/cm (60 Kg/cm) at a stirring speed of 22

rpm.

Then, 7.0 kg of organic pigment G-1 (kind:

phthalocyanine-based pigment; particle shape: granular shape;

average particle diameter: 96 nm; BET specific surface area

value: 66.4 m^2/g; L* value: 31.77; a* value: -21.28; b* value:

3.06; photofatigue resistance (ΔE* value): 9.26) was added to

the above-obtained mixture for 30 minutes while operating the

edge runner, and the resultant mixture was mixed and stirred

for 120 minutes under a linear load of 588 N/cm (60 Kg/cm) at

a stirring speed of 22 rpm, thereby forming the organic

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pigment G-1 coat onto the methylhydrogenpolysiloxane coating layer formed on the respective silica particles. Then, the obtained particles were pulverized and classified using a fluidized bed-type jet mill and a centrifugal classifier, respectively, and then dried at 80°C for 60 minutes using a dryer, thereby obtaining organic-inorganic composite pigment (G).

The thus obtained organic-inorganic composite pigment (G) was in the form of spherical particles having an average particle diameter of primary particles of 19 nm, and had a BET specific surface area value of 68.6 m^2/g, a geometrical standard deviation value of primary particles of 1.27, a volume average particle diameter (Dp_{50}) of 0.97 μm and a volume maximum particle diameter (Dp_{99}) of 1.43 μm. As to the hue of the organic-inorganic composite pigment (G), the L* value thereof was 38.69; the a* value thereof was -20.38; and the b* value thereof was 2.96. In addition, it was confirmed that the organic-inorganic composite pigment (G) had a tinting strength of 143%; a photofatigue resistance ($\Delta E*$ value) of 1.38; an organic pigment desorption degree of Rank 5; and a coating amount of methylhydrogenpolysiloxane of 2.05% by weight (calculated as C), and that the amount of the organic pigment G-1 adhered was 18.02% by weight (calculated as C; corresponding to 100 parts by weight based on 100 parts by weight of the silica particles). As a result of observing the micrograph of the obtained organic-inorganic composite pigment (G), since almost no organic pigment G-1 was recognized from the micrograph, it was confirmed that a substantially whole

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amount of the organic pigment G-1 added contributed to the

formation of the organic pigment coat on the coating layer

composed of methylhydrogenpolysiloxane.

Example 2:

<Production of organic-inorganic composite pigment (B)>

The same procedure for production of the organic-

inorganic composite pigment (G) as defined in Example 1 was

conducted except that organic pigment B-1 (kind:

phthalocyanine-based pigment; particle shape: granular shape;

average particle diameter: 83 nm; BET specific surface area

value: 81.6 m^2/g; L* value: 24.41; a* value: 6.01; b* value: -

12.63; photofatigue resistance (ΔE* value): 10.68) was used as

organic pigment, thereby obtaining organic-inorganic composite

pigment (B).

The thus obtained organic-inorganic composite pigment (B)

was in the form of spherical particles having an average

particle diameter of primary particles of 19 nm, and had a BET

specific surface area value of 65.9 m^2/g, a geometrical

standard deviation value of primary particles of 1.27, a

volume average particle diameter (Dp$_{50}$) of 0.98 μm and a

volume maximum particle diameter (Dp$_{99}$) of 1.39 μm. As to the

hue of the organic-inorganic composite pigment (B), the L*

value thereof was 26.19; the a* value thereof was 6.98; and

the b* value thereof was -11.93. In addition, it was

confirmed that the organic-inorganic composite pigment (B) had

a tinting strength of 141%; a photofatigue resistance (ΔE*

value) of 1.31; an organic pigment desorption degree of Rank

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5; and a coating amount of methylhydrogenpolysiloxane of 2.06%
by weight (calculated as C), and that the amount of the
organic pigment B-1 adhered was 33.11% by weight (calculated
as C; corresponding to 100 parts by weight based on 100 parts
by weight of the silica particles). As a result of observing
the micrograph of the obtained organic-inorganic composite
pigment (B), since almost no organic pigment B-1 was
recognized from the micrograph, it was confirmed that a
substantially whole amount of the organic pigment B-1 added
contributed to the formation of the organic pigment coat on
the coating layer composed of methylhydrogenpolysiloxane.

Example 3:

<Production of organic-inorganic composite pigment (R)>

The same procedure for production of the organic-
inorganic composite pigment (G) as defined in Example 1 was
conducted except that organic pigment R-1 (kind:
diketopyrrolopyrrole-based pigment; particle shape: granular
shape; average particle diameter: 130 nm; BET specific surface
area value: 81.6 m^2/g; L* value: 37.95; a* value: 43.24; b*
value: 23.28; photofatigue resistance (ΔE* value): 10.13) was
used as organic pigment, thereby obtaining organic-inorganic
composite pigment (R).

The thus obtained organic-inorganic composite pigment (R)
was in the form of spherical particles having an average
particle diameter of primary particles of 19 nm, and had a BET
specific surface area value of 63.8 m^2/g, a geometrical
standard deviation value of primary particles of 1.27, a

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volume average particle diameter (Dp_{50}) of 0.96 μm and a

volume maximum particle diameter (Dp_{99}) of 1.36 μm. As to the

hue of the organic-inorganic composite pigment (R), the L*

value thereof was 39.83; the a* value thereof was 42.96; and

the b* value thereof was 21.83. In addition, it was confirmed

that the organic-inorganic composite pigment (R) had a tinting

strength of 156%; a photofatigue resistance (ΔE^* value) of

1.88; an organic pigment desorption degree of Rank 5; and a

coating amount of methylhydrogenpolysiloxane of 2.08% by

weight (calculated as C), and that the amount of the organic

pigment R-1 adhered was 30.48% by weight (calculated as C;

corresponding to 100 parts by weight based on 100 parts by

weight of the silica particles). As a result of observing the

micrograph of the obtained organic-inorganic composite pigment

(R), since almost no organic pigment R-1 was recognized from

the micrograph, it was confirmed that a substantially whole

amount of the organic pigment R-1 added contributed to the

formation of the organic pigment coat on the coating layer

composed of methylhydrogenpolysiloxane.

Example 4:

<Transparent coloring composition (I): production of

transparent coloring composition (I-G)>

The organic-inorganic composite pigment (G) obtained in

Example 1, propylene glycol monomethyl ether acetate (PGMA)

and a dispersant (basic comb-shaped polymer) were kneaded

together at the following mixing ratio using a triple roll

mill.

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Organic-inorganic composite pigment (G)

100.0 parts by weight

Cyclohexanone   50.0 parts by weight

Dispersant (basic comb-shaped polymer; tradename:

"Solsperse 24000" produced by Abicia Co., Ltd.)

20.0 parts by weight

The obtained kneaded material was mixed with 230.0 parts by weight of propylene glycol monomethyl ether acetate (PGMA), and the resultant mixture was dispersed using a beads mill, thereby obtaining a transparent coloring composition (I-G).

As a result, it was confirmed that the thus obtained transparent coloring composition (I-G) had a viscosity of 10.4 mPa·s, a dispersion average particle diameter (Dd_{50}) of 65 nm, a dispersion particle diameter (Dd_{84}) of 123 nm, a dispersion maximum particle diameter (Dd_{99}) of 186 nm, a geometrical standard deviation (Dd_{84}/Dd_{50}) (as a ratio of dispersion particle diameter (Dd_{84}) to dispersion average particle diameter (Dd_{50})) of 1.89, a transmittance at wavelength of 530 nm of 81.6%, a transmittance at wavelength of 650 nm of less than 1%, and a specific absorptivity (ε_W) at wavelength of 650 nm of 2.26.

Example 5:

<u>\<Transparent coloring composition (I): production of</u>
<u>transparent coloring composition (I-B)\></u>

The same procedure for production of the transparent coloring composition (I-G) as defined in Example 4 was

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conducted except that the organic-inorganic composite pigment

(B) obtained in Example 2 was used as coloring pigment,

thereby producing a transparent coloring composition (I-B).

As a result, it was confirmed that the thus obtained

transparent coloring composition (I-B) had a viscosity of 11.3

mPa·s, a dispersion average particle diameter (Dd_{50}) of 71 nm,

a dispersion particle diameter (Dd_{84}) of 132 nm, a dispersion

maximum particle diameter (Dd_{99}) of 186 nm, a geometrical

standard deviation (Dd_{84}/Dd_{50}) of 1.86, a transmittance at

wavelength of 460 nm of 78.6%, a transmittance at wavelength

of 610 nm of less than 1%, and a specific absorptivity (ε_w) at

wavelength of 610 nm of 2.13.

Example 6:

<Transparent coloring composition (I): production of

transparent coloring composition (I-R)>

The same procedure for production of the transparent

coloring composition (I-G) as defined in Example 4 was

conducted except that the organic-inorganic composite pigment

(R) obtained in Example 3 was used as coloring pigment,

thereby producing a transparent coloring composition (I-R).

As a result, it was confirmed that the thus obtained

transparent coloring composition (I-R) had a viscosity of 7.3

mPa·s, a dispersion average particle diameter (Dd_{50}) of 88 nm,

a dispersion particle diameter (Dd_{84}) of 155 nm, a dispersion

maximum particle diameter (Dd_{99}) of 198 nm, a geometrical

standard deviation (Dd_{84}/Dd_{50}) of 1.76, a transmittance at

wavelength of 620 nm of 76.9%, a transmittance at wavelength

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of o550 nm f less than 1%, and a specific absorptivity (based on weight) (ε_w) at wavelength of 550 nm of 2.11.

Example 7:

<Transparent coloring composition (II): production of transparent coloring composition (II-G)>

The transparent coloring composition (I-G) obtained in Example 4 and a methyl methacrylate/methacrylic acid copolymer were dispersed together at the below-mentioned mixing ratio using a sand grinder. The resultant kneaded material was filtered through a 5 μm glass filter.

Transparent coloring composition (I-G)

400.0 parts by weight

Methyl methacrylate/methacrylic acid copolymer

100.0 parts by weight

As a result, it was confirmed that the thus obtained transparent coloring composition (II-G) had a viscosity of 17.3 mPa·s, a dispersion average particle diameter (Dd_{50}) of 63 nm, a dispersion particle diameter (Dd_{84}) of 111 nm, a dispersion maximum particle diameter (Dd_{99}) of 146 nm, a geometrical standard deviation (Dd_{84}/Dd_{50}) of 1.76, and a specific absorptivity (ε_w) at wavelength of 650 nm of 2.29.

Then, the transparent coloring composition (II-G) was applied onto a clear base film to form a coating layer having a thickness of 150 μm (6 mil), and then dried, thereby obtaining a colored transparent film (II-G). As a result, it was confirmed that the thus obtained colored transparent film

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(II-G) had a surface roughness Ra of 5.8 nm, a chromaticity x value of 0.2743, a chromaticity y value of 0.3786, an Y value of 71.26, a photofatigue resistance ΔE^* value of 2.56, a transmittance at wavelength of 530 nm of 92.6%, and a transmittance at wavelength of 650 nm of less than 1%.

Example 8:

<Transparent coloring composition (II): production of transparent coloring composition (II-B)>

The same procedure for production of the transparent coloring composition (II-G) as defined in Example 7 was conducted except that the transparent coloring composition (I-B) obtained in Example 5 was used as the raw transparent coloring composition, thereby obtaining a transparent coloring composition (II-B).

As a result, it was confirmed that the thus obtained transparent coloring composition (II-B) had a viscosity of 20.3 mPa·s, a dispersion average particle diameter (Dd_{50}) of 70 nm, a dispersion particle diameter (Dd_{84}) of 120 nm, a dispersion maximum particle diameter (Dd_{99}) of 153 nm, a geometrical standard deviation (Dd_{84}/Dd_{50}) of 1.71, and a specific absorptivity (ε_w) at wavelength of 610 nm of 2.29.

Then, the transparent coloring composition (II-B) was applied onto a clear base film to form a coating layer having a thickness of 150 μm (6 mil) thereon, and then dried, thereby obtaining a colored transparent film (II-B). As a result, it was confirmed that the thus obtained colored transparent film (II-B) had a surface roughness Ra of 6.1 nm, a chromaticity x

value of 0.1486, a chromaticity y value of 0.2163, an Y value of 29.41, a photofatigue resistance ΔE^* value of 2.78, a transmittance at wavelength of 460 nm of 93.0%, and a transmittance at wavelength of 610 nm of less than 1%.

Example 9:

<Transparent coloring composition (II): production of transparent coloring composition (II-R)>

The same procedure for production of the transparent coloring composition (II-G) as defined in Example 7 was conducted except that the transparent coloring composition (I-R) obtained in Example 6 was used as the raw transparent coloring composition, thereby obtaining a transparent coloring composition (II-R).

As a result, it was confirmed that the thus obtained transparent coloring composition (II-R) had a viscosity of 22.3 mPa·s, a dispersion average particle diameter (Dd_{50}) of 58 nm, a dispersion particle diameter (Dd_{84}) of 100 nm, a dispersion maximum particle diameter (Dd_{99}) of 144 nm, a geometrical standard deviation (Dd_{84}/Dd_{50}) of 1.73, and a specific absorptivity (ε_w) at wavelength of 550 nm of 2.25.

Then, the transparent coloring composition (II-R) was applied onto a clear base film to form a coating layer having a thickness of 150 μm (6 mil) thereon, and then dried, thereby obtaining a colored transparent film (II-R). As a result, it was confirmed that the thus obtained colored transparent film (II-R) had a surface roughness Ra of 6.3 nm, a chromaticity x value of 0.5673, a chromaticity y value of 0.3177, an Y value

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of 22.86, a photofatigue resistance ΔE* value of 3.65, a

transmittance at wavelength of 620 nm of 94.0%, and a

transmittance at wavelength of 550 nm of less than 1%.

Example 10:

<Transparent coloring composition (III): production of

transparent coloring composition (III-G)>

The transparent coloring composition (II-G) obtained in

Example 7, dipentaerythritol pentaacrylate and a

polymerization initiator: 2-(4-methoxy-β-styryl)-bis(4,6-

(trichloromethyl)-s-triazine were dispersed together at the

below-mentioned mixing ratio using a sand grinder. The

resultant kneaded material was filtered through a 1 μm glass

filter.

Transparent coloring composition (II-G)

480.0 parts by weight

Dipentaerythritol pentaacrylate

100.0 parts by weight

2-(4-methoxy-β-styryl)-bis(4,6-(trichloromethyl)-s-

triazine   5.0 parts by weight

As a result, it was confirmed that the thus obtained

transparent coloring composition (III-G) had a viscosity of

23.8 mPa·s, a dispersion average particle diameter (Dd_{50}) of

58 nm, a dispersion particle diameter (Dd_{84}) of 96 nm, a

dispersion maximum particle diameter (Dd_{99}) of 141 nm, a

geometrical standard deviation (Dd_{84}/Dd_{50}) of 1.66, and a

specific absorptivity ($ε_w$) at wavelength of 650 nm of 2.31.

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Then, the transparent coloring composition (III-G) was applied onto a clear base film to form a coating layer having a thickness of 150 μm (6 mil), and then dried, thereby obtaining a colored transparent film (III-G). As a result, it was confirmed that the thus obtained colored transparent film (III-G) had a surface roughness Ra of 5.8 nm, a chromaticity x value of 0.2736, a chromaticity y value of 0.3776, an Y value of 71.21, a photofatigue resistance $\Delta E*$ value of 2.51, a transmittance at wavelength of 530 nm of 93.0%, and a transmittance at wavelength of 650 nm of less than 1%.

Example 11:

<Transparent coloring composition (III): production of transparent coloring composition (III-B)>

The same procedure for production of the transparent coloring composition (III-G) as defined in Example 10 was conducted except that the transparent coloring composition (II-B) obtained in Example 8 was used as the raw transparent coloring composition, thereby obtaining a transparent coloring composition (III-B).

As a result, it was confirmed that the thus obtained transparent coloring composition (III-B) had a viscosity of 23.8 mPa·s, a dispersion average particle diameter (Dd_{50}) of 68 nm, a dispersion particle diameter (Dd_{84}) of 116 nm, a dispersion maximum particle diameter (Dd_{99}) of 159 nm, a geometrical standard deviation (Dd_{84}/Dd_{50}) of 1.71, and a specific absorptivity (ε_w) at wavelength of 610 nm of 2.29.

Then, the transparent coloring composition (III-B) was

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applied onto a clear base film to form a coating layer having

a thickness of 150 μm (6 mil) thereon, and then dried, thereby

obtaining a colored transparent film (III-B). As a result, it

was confirmed that the thus obtained colored transparent film

(III-B) had a surface roughness Ra of 5.8 nm, a chromaticity x

value of 0.1479, a chromaticity y value of 0.2170, an Y value

of 29.60, a photofatigue resistance ΔE^* value of 2.81, a

transmittance at wavelength of o460 nm f 93.3%, and a

transmittance at wavelength of 610 nm of less than 1%.

Example 12:

<Transparent coloring composition (III): production of
transparent coloring composition (III-R)>

The same procedure for production of the transparent

coloring composition (III-G) as defined in Example 10 was

conducted except that the transparent coloring composition

(II-R) obtained in Example 9 was used as the raw transparent

coloring composition, thereby obtaining a transparent coloring

composition (III-R).

As a result, it was confirmed that the thus obtained

transparent coloring composition (III-R) had a viscosity of

25.6 mPa·s, a dispersion average particle diameter (Dd_{50}) of

55 nm, a dispersion particle diameter (Dd_{84}) of 93 nm, a

dispersion maximum particle diameter (Dd_{99}) of 131 nm, a

geometrical standard deviation (Dd_{84}/Dd_{50}) of 1.69, and a

specific absorptivity (ε_w) at wavelength of 550 nm of 2.33.

Then, the transparent coloring composition (III-R) was

applied onto a clear base film to form a coating layer having

a thickness of 150 μm (6 mil) thereon, and then dried, thereby obtaining a colored transparent film (III-R). As a result, it was confirmed that the thus obtained colored transparent film (III-R) had a surface roughness Ra of 5.9 nm, a chromaticity x value of 0.5675, a chromaticity y value of 0.3163, an Y value of 22.88, a photofatigue resistance ΔE^* value of 3.59, a transmittance at wavelength of 620 nm of 94.0%, and a transmittance at wavelength of 550 nm of less than 1%.

Example 13:

<Transparent coloring composition (IV): production of transparent coloring composition (IV-G)>

The transparent coloring composition (II-G) obtained in Example 7, dipentaerythritol pentaacrylate and a photo-acid generator: p-phenylthiophenyldiphenylsulfonium trifluoroacetate were dispersed together at the below-mentioned mixing ratio using a sand grinder. The resultant kneaded material was filtered through a 1 μm glass filter.

Transparent coloring composition (II-G)

480.0 parts by weight

p-phenylthiophenyldiphenylsulfonium trifluoroacetate

5.0 parts by weight

As a result, it was confirmed that the thus obtained transparent coloring composition (IV-G) had a viscosity of 25.6 mPa·s, a dispersion average particle diameter (Dd$_{50}$) of 53 nm, a dispersion particle diameter (Dd$_{84}$) of 89 nm, a dispersion maximum particle diameter (Dd$_{99}$) of 139 nm, a

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geometrical standard deviation (Dd_{84}/Dd_{50}) of 1.68, and a

specific absorptivity (ε_w) at wavelength of 650 nm of 2.31.

Then, the transparent coloring composition (IV-G) was

applied onto a clear base film to form a coating layer having

a thickness of 150 μm (6 mil), and then dried, thereby

obtaining a colored transparent film (IV-G). As a result, it

was confirmed that the thus obtained colored transparent film

(IV-G) had a surface roughness Ra of 5.8 nm, a chromaticity x

value of 0.2742, a chromaticity y value of 0.3781, an Y value

of 71.26, a photofatigue resistance ΔE^* value of 2.53, a

transmittance at wavelength of 530 nm of 93.1%, and a

transmittance at wavelength of 650 nm of less than 1%.

Example 14:

<Transparent coloring composition (IV): production of

transparent coloring composition (IV-B)>

The same procedure for production of the transparent

coloring composition (IV-G) as defined in Example 13 was

conducted except that the transparent coloring composition

(II-B) obtained in Example 8 was used as the raw transparent

coloring composition, thereby obtaining a transparent coloring

composition (IV-B).

As a result, it was confirmed that the thus obtained

transparent coloring composition (IV-B) had a viscosity of

24.8 mPa·s, a dispersion average particle diameter (Dd_{50}) of

68 nm, a dispersion particle diameter (Dd_{84}) of 121 nm, a

dispersion maximum particle diameter (Dd_{99}) of 159 nm, a

geometrical standard deviation (Dd_{84}/Dd_{50}) of 1.78, and a

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specific absorptivity (ε_w) at wavelength of 610 nm of 2.34.

Then, the transparent coloring composition (IV-B) was applied onto a clear base film to form a coating layer having a thickness of 150 μm (6 mil) thereon, and then dried, thereby obtaining a colored transparent film (IV-B). As a result, it was confirmed that the thus obtained colored transparent film (IV-B) had a surface roughness Ra of 5.6 nm, a chromaticity x value of 0.1482, a chromaticity y value of 0.2169, an Y value of 29.68, a photofatigue resistance ΔE^* value of 2.89, a transmittance at wavelength of 460 nm of 94.1%, and a transmittance at wavelength of 610 nm of less than 1%.

Example 15:
<Transparent coloring composition (IV): production of transparent coloring composition (IV-R)>

The same procedure for production of the transparent coloring composition (IV-G) as defined in Example 13 was conducted except that the transparent coloring composition (II-R) obtained in Example 9 was used as the raw transparent coloring composition, thereby obtaining a transparent coloring composition (IV-R).

As a result, it was confirmed that the thus obtained transparent coloring composition (IV-R) had a viscosity of 31.2 mPa·s, a dispersion average particle diameter (Dd_{50}) of 58 nm, a dispersion particle diameter (Dd_{84}) of 101 nm, a dispersion maximum particle diameter (Dd_{99}) of 148 nm, a geometrical standard deviation (Dd_{84}/Dd_{50}) of 1.74, and a specific absorptivity (ε_w) at wavelength of 550 nm of 2.38.

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Then, the transparent coloring composition (IV-R) was applied onto a clear base film to form a coating layer having a thickness of 150 μm (6 mil) thereon, and then dried, thereby obtaining a colored transparent film (IV-R). As a result, it was confirmed that the thus obtained colored transparent film (IV-R) had a surface roughness Ra of 5.6 nm, a chromaticity x value of 0.5670, a chromaticity y value of 0.3159, an Y value of 28.91, a photofatigue resistance ΔE* value of 3.49, a transmittance at wavelength of 620 nm of 94.3%, and a transmittance at wavelength of 550 nm of less than 1%.

<u>Example 16:</u>
<u><Production of color filter (I)></u>

The green-based transparent coloring composition (II-G) obtained in Example 7 was spin-coated onto a 0.7 mm-thick non-alkali glass substrate on which 1.0 μm-thick resin black matrix patterns were formed, and then pre-baked at 90°C for 4 minutes using a hot plate. Thereafter, a positive photoresist was applied onto the resultant film, and then dried under heating at 80°C for 20 minutes, thereby obtaining a resist film. The thus obtained resist film was exposed to light at a luminous energy of 400 mJ/cm^2 using a 2.50 kW ultrahigh-pressure mercury lamp, and then developed with an aqueous sodium carbonate solution. An unnecessary portion of the photoresist layer was peeled off and removed using methyl cellosolve acetate. Further, the obtained colored film was heat-treated in a nitrogen atmosphere at 250°C for 30 minutes, thereby obtaining a patterned green-colored film.

Thereafter, the same procedure as defined above was

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conducted except that the transparent coloring composition

(II-B) obtained in Example 8 and the transparent coloring

composition (II-R) obtained in Example 9 were respectively

used as the raw transparent coloring composition, thereby

obtaining respective patterned colored films.

As a result, it was confirmed that the obtained color

filter (I) had a transmittance at wavelength of 620 nm of

93.5%, a transmittance at wavelength of 530 nm of 92.8%, a

transmittance at wavelength of 460 nm of 93.1%, and a contrast

of 1580.

Example 17:

<Production of color filter (II)>

The transparent coloring composition (III-G) obtained in

Example 10 was spin-coated onto a 0.7 mm-thick non-alkali

glass substrate on which 1.0 μm-thick resin black matrix

patterns were formed, and then pre-baked at 90°C for 4 minutes

on a hot plate. The thus obtained film was exposed to light

at a luminous energy of 400 mJ/cm^2 using a 2.50 kW ultrahigh-

pressure mercury lamp, and then developed with an aqueous

sodium carbonate solution to remove an unexposed portion of

the photoresist layer. Further, the obtained colored film was

heat-treated in a nitrogen atmosphere at 250°C for 30 minutes,

thereby obtaining a patterned green-colored film.

Thereafter, the same procedure as defined above was

conducted except that the transparent coloring composition

(III-B) obtained in Example 11 and the transparent coloring

composition (III-R) obtained in Example 12 were respectively

used as the raw transparent coloring composition, thereby

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obtaining respective patterned colored films.

As a result, it was confirmed that the obtained color filter (II) had a transmittance at wavelength of 620 nm of 94.0%, a transmittance at wavelength of 530 nm of 93.0%, a transmittance at wavelength of 460 nm of 93.3%, and a contrast of 1790.

Example 18:

<Production of color filter (III)>

The same procedure for production of the color filter (II) as defined in Example 17 was conducted except that the transparent coloring composition (IV-G) obtained in Example 13, the transparent coloring composition (IV-B) obtained in Example 14 and the transparent coloring composition (IV-R) obtained in Example 15 were respectively used as the raw transparent coloring composition, thereby obtaining a color filter (III).

As a result, it was confirmed that the obtained color filter (III) had a transmittance at wavelength of 620 nm of 94.3%, a transmittance at wavelength of 530 nm of 93.1%, a transmittance at wavelength of 460 nm of 94.1%, and a contrast of 1630.

Core particles 1 to 4:

Fine white inorganic particles having properties shown in Table 1 were prepared as core particles 1 to 4.

Core particles 5:

A slurry containing silica particles was obtained by

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dispersing 20 kg of silica particles (core particles 1) in 150

liters of water. The pH value of the thus obtained re-

dispersed slurry containing the silica particles was adjusted

to 10.5 using an aqueous sodium hydroxide solution, and then

the slurry concentration was adjusted to 98 g/liter by adding

water thereto. After 150 liters of the slurry was heated to

60°C, 2,722 ml of a 1.0 mol/liter sodium aluminate solution

(corresponding to 0.5% by weight (calculated as Al) based on

the weight of the silica particles) was added to the slurry.

After allowing the obtained slurry to stand for 30 minutes,

the pH value of the slurry was adjusted to 7.5 by using acetic

acid. After further allowing the resultant slurry to stand

for 30 minutes, the slurry was subjected to filtration,

washing with water, drying and pulverization, thereby

obtaining the silica particles whose surface was coated with.

hydroxides of aluminum.

The essential production conditions are shown in Table 2,

and various properties of the obtained surface-treated silica

particles are shown in Table 3.

Core particles 6 and 7:

The same procedure as defined in the production of the

above core particles 5, was conducted except that the core

particles 2 and 3 were respectively used as the fine white

inorganic particles, and kinds and amounts of surface-coating

materials were changed variously, thereby obtaining fine white

inorganic particles whose surface was coated with the surface-

coating material.

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The essential production conditions are shown in Table 2, and various properties of the obtained surface-treated fine white inorganic particles are shown in Table 3.

Meanwhile, in Tables, "A" and "S" as described in "kind of coating material used in surface-treating step" represent hydroxides of aluminum and oxides of silicon, respectively.

Organic pigments:

Organic pigments having properties as shown in Table 4 were prepared.

Examples 19 to 37, Comparative Examples 1 to 6 and Reference Examples 1 to 3:

The same procedures as defined in Examples 1 to 3 were conducted except that kinds and amounts of additives added in coating step with surface modifier, linear load and treating time for edge runner treatment used in the coating step with surface modifier, kinds and amounts of organic pigments adhered in organic pigment-adhering step, linear load and treating time for edge runner treatment used in the organic pigment-adhering step, and use and non-use of pulverization and classification, were changed variously, thereby obtaining organic-inorganic composite pigments.

The essential production conditions are shown in Tables 5 and 6, and various properties of the obtained organic-inorganic composite pigments are shown in Tables 7 and 8.

Meanwhile, in Examples 19 to 23, 36 and 37, Comparative Examples 1 to 6 and Reference Examples 1 to 3, the respective

organic pigments were added five times in an amount of 20.0 g
each to 100.0 g of the core particles such that the total
amount of the respective organic pigments added was 100.0 g.
In Examples 30 to 32, 200.0 g of the respective organic
pigments were continuously added to 100.0 g of the core
particles for 200 minutes. In Examples 24 to 26, after the
respective organic pigments were previously mixed together
using a Henschel mixer, etc., the thus obtained mixed pigments
were added eight times in an amount of 20.0 g each to 100.0 g
of the core particles such that the total amount of the
respective organic pigments added was 160.0 g. In Examples 27
to 29 and 33 to 35, the respective organic pigments were added
six times in an amount of 20.0 g each to 100.0 g of the core
particles such that the total amount of the respective organic
pigments added was 120.0 g.

Examples 38 to 56, Comparative Examples 7 to 15 and Reference
Examples 4 to 6:
<Transparent coloring composition (I)>

The same procedures for production of the transparent
coloring composition (I) as defined in Examples 4 to 6 were
conducted except that kinds of organic-inorganic composite
pigments, kinds and amounts of dispersants blended, and kinds
and amounts of solvents blended, were changed variously,
thereby obtaining transparent coloring compositions (I).

The essential production conditions are shown in Tables 9
and 10, and various properties of the obtained transparent
coloring compositions (I) are shown in Tables 11 and 12.

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Examples 57 to 75, Comparative Examples 16 to 24 and Reference
Examples 7 to 9:

<Transparent coloring composition (II)>

The same procedures for production of the transparent
coloring composition (II) as defined in Examples 7 to 9 were
conducted except that amounts of transparent coloring
compositions (I) blended, and kinds and amounts of transparent
resins blended, were changed variously, thereby obtaining
transparent coloring compositions (II).

The essential production conditions are shown in Tables
13 and 14, various properties of the obtained transparent
coloring compositions (II) are shown in Tables 15 and 16, and
various properties of the colored transparent films (II)
obtained by coating the transparent coloring compositions (II)
are shown in Tables 17 and 18.

Examples 79 to 94, Comparative Examples 25 to 33 and Reference
Examples 10 to 12:

<Transparent coloring composition (III)>

The same procedures for production of the transparent
coloring composition (III) as defined in Examples 10 to 12
were respectively conducted except that kinds and amounts of
transparent coloring compositions (II) blended, kinds and
amounts of polyfunctional monomers blended, and kinds and
amounts of polymerization initiators blended, were changed
variously, thereby obtaining transparent coloring compositions
(III).

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The essential production conditions are shown in Tables 19 and 20, various properties of the obtained transparent coloring compositions (III) are shown in Tables 21 and 22, and various properties of the colored transparent films (III) obtained by coating the transparent coloring compositions (III) are shown in Tables 23 and 24.

Examples 95 to 113, Comparative Examples 34 to 42 and Reference Examples 13 to 15:

<Transparent coloring composition (IV)>

The same procedures for production of the transparent coloring composition (IV) as defined in Examples 13 to 15 were respectively conducted except that kinds and amounts of transparent coloring compositions (II) blended, and kinds and amounts of photo-acid generators blended, were changed variously, thereby obtaining transparent coloring compositions (IV).

The essential production conditions are shown in Tables 25 and 26, various properties of the obtained transparent coloring compositions (IV) are shown in Tables 27 and 28, and various properties of the colored transparent films (IV) obtained by coating the transparent coloring compositions (IV) are shown in Tables 29 and 30.

<Color filter>

Examples 114 to 117, Comparative Examples 43 to 45 and Reference Example 16:

The same procedure for production of the color filter (I)

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as defined in Example 16 was conducted except that kinds of
transparent coloring compositions were changed variously,
thereby obtaining color filters.

The essential production conditions and various
properties of the obtained color filters are shown in Tables
31 and 32.

Examples 118 to 121, Comparative Examples 46 to 48 and

Reference Example 17:

The same procedure for production of the color filter
(II) as defined in Example 17 was conducted except that kinds
of transparent coloring compositions were changed variously,
thereby obtaining color filters.

The essential production conditions and various
properties of the obtained color filters are shown in Tables
31 and 32.

Examples 122 to 125, Comparative Examples 49 to 51 and

Reference Example 18:

The same procedure for production of the color filter
(III) as defined in Example 18 was conducted except that kinds
of transparent coloring compositions were changed variously,
thereby obtaining color filters.

The essential production conditions and various
properties of the obtained color filters are shown in Tables
31 and 32.

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Table 1

Kind of core particles	Properties of fine white inorganic particles			
	Kind	Shape	Average particle diameter of primary particles (nm)	Geometrical standard deviation (-)
Core particles 1	Silica	Spherical	20	1.25
Core particles 2	Silica	Spherical	11	1.27
Core particles 3	Precipitated barium sulfate	Granular	30	1.48
Core particles 4	Titanium oxide	Granular	36	1.38

Table 1 (continued)

Kind of core particles	Properties of fine white inorganic particles			
	BET specific surface area value (m²/g)	Volume average particle diameter (Dp_{50}) (μm)	Volume maximum particle diameter (Dp_{99}) (μm)	Refractive index (-)
Core particles 1	201.3	1.63	2.59	1.42
Core particles 2	303.8	1.87	3.12	1.42
Core particles 3	31.6	1.56	2.68	1.62
Core particles 4	61.2	1.96	3.26	2.71

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Table 1 (continued)

Kind of core particles	Properties of fine white inorganic particles				
	Hue				Photofatigue resistance ΔE^* value (-)
	L* value (-)	a* value (-)	b* value (-)	C* value (-)	
Core particles 1	93.36	0.13	0.25	0.28	5.36
Core particles 2	93.13	0.11	1.16	1.17	5.38
Core particles 3	94.16	0.23	0.84	0.87	4.64
Core particles 4	98.16	0.08	0.96	0.96	8.64

Table 2

Kind of core particles	Kind of core particles	Surface-treating step		
		Additives		
		Kind	Calculated as	Amount (wt. %)
Core particles 5	Core particles 1	Sodium aluminate	Al	0.5
Core particles 6	Core particles 2	Aluminum sulfate	Al	1.0
Core particles 7	Core particles 3	Sodium aluminate	Al	0.5
		Water glass #3	SiO_2	1.0

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Table 2 (continued)

Kind of core particles	Surface-treating step		
	Coating material		
	Kind	Calculated as	Amount (wt. %)
Core particles 5	A	Al	0.49
Core particles 6	A	Al	0.99
Core particles 7	A	Al	0.49
	S	SiO$_2$	0.98

Table 3

Kind of core particles	Properties of surface-treated fine white inorganic particles		
	Shape	Average particle diameter of primary particles (nm)	Geometrical standard deviation (-)
Core particles 5	Spherical	20	1.25
Core particles 6	Spherical	11	1.27
Core particles 7	Granular	30	1.47

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Table 3 (continued)

Kind of core particles	Properties of surface-treated fine white inorganic particles			
	BET specific surface area value (m²/g)	Volume average particle diameter (Dp₅₀) (μm)	Volume maximum particle diameter (Dp₉₉) (μm)	Refractive index (-)
Core particles 5	196.4	1.96	3.87	1.42
Core particles 6	286.3	2.83	4.86	1.42
Core particles 7	29.8	2.06	3.73	1.62

Table 3 (continued)

Kind of core particles	Properties of surface-treated fine white inorganic particles				Photofatigue resistance ΔE* value (-)
	Hue				
	L* value (-)	a* value (-)	b* value (-)	C* value (-)	
Core particles 5	93.11	0.15	0.28	0.32	4.36
Core particles 6	92.96	0.13	1.13	1.14	4.96
Core particles 7	93.93	0.28	0.76	0.81	4.23

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Table 4

Organic pigments	Properties of organic pigment
	Kind
Organic pigment B-1	Pigment blue (phthalocyanine-based pigment)
Organic pigment G-1	Pigment green (phthalocyanine-based pigment)
Organic pigment R-1	Pigment red (diketopyrrolopyrrole-based pigment)
Organic pigments R-2	Pigment red (anthraquinone-based pigment)
Organic pigment V-1	Pigment violet (dioxazine-based pigment)
Organic pigment Y-1	Pigment yellow (quinophthalone-based pigment)

Table 4 (continued)

Organic pigments	Properties of organic pigment		
	Particle shape	Average particle diameter of primary particles (nm)	BET specific surface area value (m²/g)
Organic pigment B-1	Granular	83	81.6
Organic pigment G-1	Granular	96	66.4
Organic pigment R-1	Granular	130	81.6
Organic pigments R-2	Granular	121	41.6
Organic pigment V-1	Granular	107	52.6
Organic pigment Y-1	Granular	131	31.3

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Table 4 (continued)

Organic pigments	Properties of organic pigment			
	Hue			Photofatigue resistance (ΔE* value) (-)
	L* value (-)	a* value (-)	b* value (-)	
Organic pigment B-1	24.41	6.01	-12.63	10.68
Organic pigment G-1	31.77	-21.28	3.06	9.26
Organic pigment R-1	37.95	43.24	23.28	10.13
Organic pigments R-2	54.13	56.75	43.86	13.64
Organic pigment V-1	25.57	5.99	1.07	15.16
Organic pigment Y-1	61.05	16.93	44.80	15.18

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Table 5

Examples	Kind of core particles
Example 19	Core particles 1
Example 20	Core particles 1
Example 21	Core particles 1
Example 22	Core particles 1
Example 23	Core particles 1
Example 24	Core particles 1
Example 25	Core particles 1
Example 26	Core particles 1
Example 27	Core particles 2
Example 28	Core particles 2
Example 29	Core particles 2
Example 30	Core particles 3
Example 31	Core particles 3
Example 32	Core particles 3
Example 33	Core particles 5
Example 34	Core particles 5
Example 35	Core particles 5
Example 36	Core particles 6
Example 37	Core particles 7

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Table 5 (continued)

Examples	Production of organic and inorganic composite pigment	
	Coating step with surface modifying agent	
	Additives	
	Kind	Amount added (wt. part)
Example 19	Methylhydrogenpolysiloxane	4.0
Example 20	Methylhydrogenpolysiloxane	2.0
Example 21	Methylhydrogenpolysiloxane	6.0
Example 22	Methylhydrogenpolysiloxane	8.0
Example 23	Methylhydrogenpolysiloxane	4.0
Example 24	Methyltrimethoxysilane	2.0
Example 25	Methyltrimethoxysilane	3.0
Example 26	Methyltrimethoxysilane	6.0
Example 27	Methyltriethoxysilane	8.0
Example 28	Methyltriethoxysilane	6.0
Example 29	Methyltriethoxysilane	12.0
Example 30	Phenyltriethoxysilane	6.0
Example 31	Phenyltriethoxysilane	6.0
Example 32	Phenyltriethoxysilane	4.0
Example 33	Methylhydrogenpolysiloxane	2.0
Example 34	Methylhydrogenpolysiloxane	10.0
Example 35	Methylhydrogenpolysiloxane	5.0
Example 36	γ-aminopropyltriethoxysilane	20.0
Example 37	Polyvinyl alcohol	15.0

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Table 5 (continued)

Examples	Production of organic and inorganic composite pigment			
	Coating step with surface modifying agent			
	Edge runner treatment			Coating amount (calculated as C) (wt. %)
	Linear load		Time (min.)	
	(N/cm)	(Kg/cm)		
Example 19	588	60	120	1.04
Example 20	392	40	60	0.52
Example 21	784	80	180	1.52
Example 22	735	75	60	2.00
Example 23	490	50	40	1.05
Example 24	441	45	120	0.17
Example 25	588	60	60	0.26
Example 26	294	30	40	0.51
Example 27	735	75	160	0.49
Example 28	588	60	100	0.38
Example 29	588	60	60	0.72
Example 30	588	60	85	2.06
Example 31	735	75	90	2.05
Example 32	441	45	100	1.38
Example 33	343	35	120	0.52
Example 34	441	45	140	2.44
Example 35	588	60	180	1.30
Example 36	588	60	50	2.74
Example 37	441	45	120	7.08

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Table 5 (continued)

Examples	Production of organic and inorganic composite pigment			
	Organic pigment-adhesion step			
	Organic pigment		Organic pigment	
	Kind	Amount adhered (wt. part)	Kind	Amount adhered (wt. part)
Example 19	B-1	100.0	−	−
Example 20	G-1	100.0	−	−
Example 21	R-1	100.0	−	−
Example 22	R-2	100.0	−	−
Example 23	Y-1	100.0	−	−
Example 24	B-1	150.0	V-1	10.0
Example 25	G-1	150.0	Y-1	10.0
Example 26	R-1	150.0	Y-1	10.0
Example 27	B-1	120.0	−	−
Example 28	G-1	120.0	−	−
Example 29	R-1	120.0	−	−
Example 30	B-1	200.0	−	−
Example 31	G-1	200.0	−	−
Example 32	R-1	200.0	−	−
Example 33	B-1	120.0	−	−
Example 34	G-1	120.0	−	−
Example 35	R-1	120.0	−	−
Example 36	B-1	100.0	−	−
Example 37	G-1	100.0	−	−

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Table 5 (continued)

Examples	Production of organic and inorganic composite pigment			
	Organic pigment-adhesion step			
	Edge runner treatment			Amount adhered (calculated as C) (wt. %)
	Linear load		Time (min.)	
	(N/cm)	(Kg/cm)		
Example 19	588	60	60	33.06
Example 20	588	60	120	18.63
Example 21	441	45	60	30.16
Example 22	735	75	90	37.68
Example 23	588	60	60	22.32
Example 24	588	60	120	40.85
Example 25	441	45	180	21.56
Example 26	588	60	160	46.79
Example 27	735	75	180	36.16
Example 28	343	35	120	19.58
Example 29	392	40	90	33.03
Example 30	588	60	120	44.72
Example 31	784	80	180	24.01
Example 32	588	60	120	40.42
Example 33	588	60	140	36.66
Example 34	392	40	120	20.11
Example 35	441	45	160	33.38
Example 36	735	75	120	33.68
Example 37	588	60	120	18.49

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Table 5 (continued)

Examples	Production of organic and inorganic composite pigment	
	Pulverization and classification	
	Use or non-use of pulverization	Use or non-use of classification
Example 19	Used	Used
Example 20	Used	Used
Example 21	Used	Used
Example 22	Used	Used
Example 23	Used	Used
Example 24	Used	Used
Example 25	Used	Used
Example 26	Used	Used
Example 27	Used	Used
Example 28	Used	Used
Example 29	Used	Used
Example 30	Used	Used
Example 31	Used	Used
Example 32	Used	Used
Example 33	Used	Used
Example 34	Used	Used
Example 35	Used	Used
Example 36	Used	Used
Example 37	Used	Used

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Table 6

Comparative Examples and Reference Examples	Kind of core particles
Comparative Example 1	Core particles 1
Comparative Example 2	Core particles 1
Comparative Example 3	Core particles 1
Comparative Example 4	Core particles 4
Comparative Example 5	Core particles 4
Comparative Example 6	Core particles 4
Reference Example 1	Core particles 1
Reference Example 2	Core particles 1
Reference Example 3	Core particles 1

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Table 6 (continued)

Comparative Examples and Reference Examples	Production of organic and inorganic composite pigment	
	Coating step with surface modifying agent	
	Additives	
	Kind	Amount added (wt. part)
Comparative Example 1	−	−
Comparative Example 2	−	−
Comparative Example 3	−	−
Comparative Example 4	Methylhydrogenpolysiloxane	0.005
Comparative Example 5	Methylhydrogenpolysiloxane	0.005
Comparative Example 6	Methylhydrogenpolysiloxane	0.005
Reference Example 1	Methylhydrogenpolysiloxane	4.0
Reference Example 2	Methylhydrogenpolysiloxane	4.0
Reference Example 3	Methylhydrogenpolysiloxane	4.0

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Table 6 (continued)

Comparative Examples and Reference Examples	Production of organic and inorganic composite pigment			
	Coating step with surface modifying agent			
	Edge runner treatment			Coating amount (calculated as C) (wt. %)
	Linear load		Time (min.)	
	(N/cm)	(Kg/cm)		
Comparative Example 1	–	–	–	–
Comparative Example 2	–	–	–	–
Comparative Example 3	–	–	–	–
Comparative Example 4	588	60	120	2×10^{-3}
Comparative Example 5	588	60	120	2×10^{-3}
Comparative Example 6	588	60	120	2×10^{-3}
Reference Example 1	588	60	120	1.03
Reference Example 2	588	60	120	1.04
Reference Example 3	588	60	120	1.04

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Table 6 (continued)

Comparative Examples and Reference Examples	Production of organic and inorganic composite pigment			
	Organic pigment-adhesion step			
	Organic pigment		Organic pigment	
	Kind	Amount adhered (wt. part)	Kind	Amount adhered (wt. part)
Comparative Example 1	B-1	100.0	-	-
Comparative Example 2	G-1	100.0	-	-
Comparative Example 3	R-1	100.0	-	-
Comparative Example 4	B-1	100.0	-	-
Comparative Example 5	G-1	100.0	-	-
Comparative Example 6	R-1	100.0	-	-
Reference Example 1	B-1	100.0	-	-
Reference Example 2	G-1	100.0	-	-
Reference Example 3	R-1	100.0	-	-

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Table 6 (continued)

Comparative Examples and Reference Examples	Production of organic and inorganic composite pigment			
	Organic pigment-adhesion step			
	Edge runner treatment			Amount adhered (calculated as C) (wt. %)
	Linear load		Time (min.)	
	(N/cm)	(Kg/cm)		
Comparative Example 1	588	60	60	33.69
Comparative Example 2	588	60	60	18.14
Comparative Example 3	588	60	60	30.64
Comparative Example 4	588	60	60	33.00
Comparative Example 5	588	60	60	18.96
Comparative Example 6	588	60	60	29.98
Reference Example 1	588	60	60	33.55
Reference Example 2	588	60	60	18.01
Reference Example 3	588	60	60	30.76

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Table 6 (continued)

Comparative Examples and Reference Examples	Production of organic and inorganic composite pigment	
	Pulverization and classification	
	Use or non-use of pulverization	Use or non-use of classification
Comparative Example 1	Non-used	Non-used
Comparative Example 2	Non-used	Non-used
Comparative Example 3	Non-used	Non-used
Comparative Example 4	Used	Used
Comparative Example 5	Used	Used
Comparative Example 6	Used	Used
Reference Example 1	Non-used	Non-used
Reference Example 2	Non-used	Non-used
Reference Example 3	Non-used	Non-used

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Table 7

Examples	Properties of organic and inorganic composite pigment		
	Average particle diameter of primary particles (nm)	Geometrical standard deviation (-)	BET specific surface area value (m^2/g)
Example 19	22	1.25	61.2
Example 20	23	1.26	64.6
Example 21	24	1.25	58.6
Example 22	22	1.25	56.3
Example 23	24	1.25	58.6
Example 24	23	1.26	46.3
Example 25	22	1.25	48.2
Example 26	23	1.26	50.6
Example 27	14	1.28	81.2
Example 28	13	1.27	86.8
Example 29	14	1.28	80.1
Example 30	32	1.48	40.1
Example 31	33	1.48	42.8
Example 32	32	1.48	43.2
Example 33	22	1.25	58.6
Example 34	23	1.25	56.3
Example 35	24	1.26	60.1
Example 36	13	1.28	75.3
Example 37	32	1.48	46.8

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Table 7 (continued)

Examples	Properties of organic and inorganic composite pigment	
	Volume average particle diameter (Dp_{50}) (μm)	Volume maximum particle diameter (Dp_{99}) (μm)
Example 19	0.96	1.43
Example 20	0.83	1.51
Example 21	0.76	1.46
Example 22	0.64	1.47
Example 23	0.91	1.38
Example 24	1.08	1.46
Example 25	1.16	1.40
Example 26	0.93	1.48
Example 27	1.13	1.63
Example 28	1.06	1.59
Example 29	1.11	1.61
Example 30	0.78	0.96
Example 31	0.69	1.13
Example 32	0.83	1.18
Example 33	0.86	1.46
Example 34	0.91	1.40
Example 35	0.83	1.46
Example 36	0.90	1.50
Example 37	0.59	1.13

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Table 7 (continued)

Examples	Properties of organic and inorganic composite pigment		
	Hue		
	L* value (-)	a* value (-)	b* value (-)
Example 19	26.13	7.01	-11.62
Example 20	38.16	-20.12	3.01
Example 21	39.60	42.16	21.63
Example 22	55.68	54.13	41.62
Example 23	63.96	15.16	42.23
Example 24	23.16	7.23	-14.65
Example 25	32.63	-21.69	6.83
Example 26	38.16	41.62	25.33
Example 27	25.13	5.32	-11.01
Example 28	33.63	-20.16	2.54
Example 29	38.62	42.86	22.18
Example 30	26.83	6.36	-11.92
Example 31	34.16	-19.72	2.83
Example 32	39.62	40.63	24.16
Example 33	25.63	4.92	-11.83
Example 34	32.64	-22.65	2.93
Example 35	39.68	42.26	21.69
Example 36	25.63	5.63	-10.93
Example 37	32.68	-21.63	2.96

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Table 7 (continued)

Examples	Properties of organic and inorganic composite pigment		
	Tinting strength (%)	Photofatigue resistance (ΔE^* value) (-)	Desorption degree of organic pigment (-)
Example 19	138	1.38	5
Example 20	148	1.26	5
Example 21	161	1.96	5
Example 22	160	1.83	5
Example 23	158	2.26	4
Example 24	171	1.48	5
Example 25	169	1.36	4
Example 26	166	2.03	5
Example 27	146	1.36	4
Example 28	154	1.35	4
Example 29	168	1.29	4
Example 30	213	1.68	5
Example 31	221	1.74	5
Example 32	206	1.83	5
Example 33	163	1.26	5
Example 34	158	1.23	5
Example 35	159	1.41	5
Example 36	146	1.16	4
Example 37	143	1.08	5

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Table 8

Comparative Examples and Reference Examples	Properties of organic and inorganic composite pigment		
	Average particle diameter of primary particles (nm)	Geometrical standard deviation (-)	BET specific surface area value (m²/g)
Comparative Example 1	21	2.56	128.1
Comparative Example 2	21	2.63	138.2
Comparative Example 3	21	2.79	140.6
Comparative Example 4	38	2.38	73.1
Comparative Example 5	37	2.35	68.3
Comparative Example 6	38	2.36	76.2
Reference Example 1	23	1.26	68.3
Reference Example 2	24	1.27	78.6
Reference Example 3	23	1.26	71.6

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Table 8 (continued)

Comparative Examples and Reference Examples	Properties of organic and inorganic composite pigment	
	Volume average particle diameter (Dp_{50}) (μm)	Volume maximum particle diameter (Dp_{99}) (μm)
Comparative Example 1	6.58	26.35
Comparative Example 2	6.64	25.91
Comparative Example 3	6.62	25.82
Comparative Example 4	4.93	11.14
Comparative Example 5	4.86	11.36
Comparative Example 6	4.92	11.98
Reference Example 1	5.65	12.60
Reference Example 2	5.52	12.54
Reference Example 3	5.46	12.43

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Table 8 (continued)

Comparative Examples and Reference Examples	Properties of organic and inorganic composite pigment		
	Hue		
	L* value (-)	a* value (-)	b* value (-)
Comparative Example 1	29.16	5.12	-9.14
Comparative Example 2	40.13	-18.16	2.12
Comparative Example 3	43.56	39.16	19.62
Comparative Example 4	31.62	6.66	-10.62
Comparative Example 5	43.16	-18.63	2.96
Comparative Example 6	45.16	40.66	20.92
Reference Example 1	28.32	5.56	-9.92
Reference Example 2	40.11	-19.16	2.56
Reference Example 3	42.63	40.16	20.66

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Table 8 (continued)

Comparative Examples and Reference Examples	Properties of organic and inorganic composite pigment		
	Tinting strength (%)	Photofatigue resistance (ΔE* value) (-)	Desorption degree of organic pigment (-)
Comparative Example 1	100	7.12	1
Comparative Example 2	100	5.99	1
Comparative Example 3	100	6.48	1
Comparative Example 4	103	10.16	1
Comparative Example 5	106	11.21	1
Comparative Example 6	105	11.83	1
Reference Example 1	132	1.52	5
Reference Example 2	135	1.36	5
Reference Example 3	131	2.00	4

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Table 9

Examples	Production of transparent coloring composition (I)	
	Coloring pigment	
	Kind	Amount blended (wt. part)
Example 38	Example 19	100.0
Example 39	Example 20	100.0
Example 40	Example 21	100.0
Example 41	Example 22	100.0
Example 42	Example 23	100.0
Example 43	Example 24	100.0
Example 44	Example 25	100.0
Example 45	Example 26	100.0
Example 46	Example 27	100.0
Example 47	Example 28	100.0
Example 48	Example 29	100.0
Example 49	Example 30	100.0
Example 50	Example 31	100.0
Example 51	Example 32	100.0
Example 52	Example 33	100.0
Example 53	Example 34	100.0
Example 54	Example 35	100.0
Example 55	Example 36	100.0
Example 56	Example 37	100.0

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Table 9 (continued)

Examples	Production of transparent coloring composition (I)	
	Dispersant	
	Kind	Amount blended (wt. part)
Example 38	Basic comb-shaped polymer	20.0
Example 39	Basic comb-shaped polymer	20.0
Example 40	Basic comb-shaped polymer	20.0
Example 41	Phenyl ether-based nonionic surfactant	15.0
Example 42	Sulfonic acid salt dispersant	30.0
Example 43	Modified acrylic block copolymer	25.0
Example 44	Modified acrylic block copolymer	25.0
Example 45	Modified acrylic block copolymer	25.0
Example 46	Polyester acid amide amine	10.0
Example 47	Polyester acid amide amine	10.0
Example 48	Polyester acid amide amine	10.0
Example 49	Phenyl ether-based nonionic surfactant	30.0
Example 50	Phenyl ether-based nonionic surfactant	30.0
Example 51	Phenyl ether-based nonionic surfactant	30.0
Example 52	Basic comb-shaped polymer	15.0
Example 53	Basic comb-shaped polymer	15.0
Example 54	Basic comb-shaped polymer	15.0
Example 55	Polyether-based phosphoric acid ester	40.0
Example 56	Phenyl ether-based nonionic surfactant	20.0

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Table 9 (continued)

Examples	Production of transparent coloring composition (I)			
	Solvent			
	Kind	Amount blended (wt. part)	Kind	Amount blended (wt. part)
Example 38	Cyclohexanone	50.0	PGMA	230.0
Example 39	Cyclohexanone	50.0	PGMA	230.0
Example 40	Cyclohexanone	50.0	PGMA	230.0
Example 41	Cyclohexanone	50.0	PGMA	225.0
Example 42	Cyclohexanone	50.0	PGMA	240.0
Example 43	Cyclohexanone	50.0	PGMA	245.0
Example 44	Cyclohexanone	50.0	PGMA	245.0
Example 45	Cyclohexanone	50.0	PGMA	245.0
Example 46	Cyclohexanone	50.0	PGMA	220.0
Example 47	Cyclohexanone	50.0	PGMA	220.0
Example 48	Cyclohexanone	50.0	PGMA	220.0
Example 49	Cyclohexanone	50.0	PGMA	240.0
Example 50	Cyclohexanone	50.0	PGMA	240.0
Example 51	Cyclohexanone	50.0	PGMA	240.0
Example 52	Cyclohexanone	50.0	PGMA	225.0
Example 53	Cyclohexanone	50.0	PGMA	225.0
Example 54	Cyclohexanone	50.0	PGMA	225.0
Example 55	Cyclohexanone	50.0	PGMA	250.0
Example 56	Cyclohexanone	50.0	PGMA	230.0

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Table 10

Comparative Examples and Reference Examples	Production of transparent coloring composition (I)	
	Coloring pigment	
	Kind	Amount blended (wt. part)
Comparative Example 7	Organic pigment B-1	100.0
Comparative Example 8	Organic pigment G-1	100.0
Comparative Example 9	Organic pigment R-1	100.0
Comparative Example 10	Comparative Example 1	100.0
Comparative Example 11	Comparative Example 2	100.0
Comparative Example 12	Comparative Example 3	100.0
Comparative Example 13	Comparative Example 4	100.0
Comparative Example 14	Comparative Example 5	100.0
Comparative Example 15	Comparative Example 6	100.0
Reference Example 4	Reference Example 1	100.0
Reference Example 5	Reference Example 2	100.0
Reference Example 6	Reference Example 3	100.0

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Table 10 (continued)

Comparative Examples and Reference Examples	Production of transparent coloring composition (I)	
	Dispersant	
	Kind	Amount blended (wt. part)
Comparative Example 7	Modified acrylic block copolymer	20.0
Comparative Example 8	Modified acrylic block copolymer	20.0
Comparative Example 9	Modified acrylic block copolymer	20.0
Comparative Example 10	Modified acrylic block copolymer	20.0
Comparative Example 11	Modified acrylic block copolymer	20.0
Comparative Example 12	Modified acrylic block copolymer	20.0
Comparative Example 13	Modified acrylic block copolymer	20.0
Comparative Example 14	Modified acrylic block copolymer	20.0
Comparative Example 15	Modified acrylic block copolymer	20.0
Reference Example 4	Modified acrylic block copolymer	20.0
Reference Example 5	Modified acrylic block copolymer	20.0
Reference Example 6	Modified acrylic block copolymer	20.0

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Table 10 (continued)

Comparative Examples and Reference Examples	Production of transparent coloring composition (I)			
	Solvent			
	Kind	Amount blended (wt. part)	Kind	Amount blended (wt. part)
Comparative Example 7	Cyclohexanone	50.0	PGMA	230.0
Comparative Example 8	Cyclohexanone	50.0	PGMA	230.0
Comparative Example 9	Cyclohexanone	50.0	PGMA	230.0
Comparative Example 10	Cyclohexanone	50.0	PGMA	230.0
Comparative Example 11	Cyclohexanone	50.0	PGMA	230.0
Comparative Example 12	Cyclohexanone	50.0	PGMA	230.0
Comparative Example 13	Cyclohexanone	50.0	PGMA	230.0
Comparative Example 14	Cyclohexanone	50.0	PGMA	230.0
Comparative Example 15	Cyclohexanone	50.0	PGMA	230.0
Reference Example 4	Cyclohexanone	50.0	PGMA	230.0
Reference Example 5	Cyclohexanone	50.0	PGMA	230.0
Reference Example 6	Cyclohexanone	50.0	PGMA	230.0

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Table 11

Examples	Properties of transparent coloring composition (I)		
	Viscosity (mPa·s)	Dispersion average particle diameter (Dd_{50}) (nm)	Dispersion particle diameter (Dd_{84}) (nm)
Example 38	10.3	68	126
Example 39	9.6	76	147
Example 40	6.8	103	173
Example 41	5.4	56	81
Example 42	7.3	43	72
Example 43	8.2	26	59
Example 44	3.6	31	61
Example 45	2.3	63	134
Example 46	11.3	78	131
Example 47	16.8	81	140
Example 48	21.3	96	158
Example 49	6.8	113	150
Example 50	5.6	32	58
Example 51	8.3	65	109
Example 52	9.6	68	118
Example 53	10.3	103	147
Example 54	11.2	86	144
Example 55	16.8	89	153
Example 56	8.4	96	171

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Table 11 (continued)

Examples	Properties of transparent coloring composition (I)	
	Dispersion maximum particle diameter (Dd_{99}) (nm)	Geometrical standard deviation (Dd_{84}/Dd_{50}) (−)
Example 38	193	1.86
Example 39	226	1.93
Example 40	256	1.68
Example 41	122	1.45
Example 42	108	1.68
Example 43	100	2.25
Example 44	118	1.96
Example 45	168	2.13
Example 46	193	1.68
Example 47	168	1.73
Example 48	173	1.65
Example 49	216	1.33
Example 50	116	1.82
Example 51	183	1.68
Example 52	176	1.73
Example 53	192	1.44
Example 54	201	1.68
Example 55	211	1.72
Example 56	216	1.78

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Table 11 (continued)

Examples	Properties of transparent coloring composition (I)			
	Transmittance (R)		Transmittance (G)	
	620 nm (%)	550 nm (%)	530 nm (%)	650 nm (%)
Example 38	−	−	−	−
Example 39	−	−	81.3	<1
Example 40	76.3	<1	−	−
Example 41	78.3	<1	−	−
Example 42	−	−	−	−
Example 43	−	−	−	−
Example 44	−	−	82.6	<1
Example 45	83.4	<1	−	−
Example 46	−	−	−	−
Example 47	−	−	78.3	<1
Example 48	77.6	<1	−	−
Example 49	−	−	−	−
Example 50	−	−	81.3	<1
Example 51	76.7	<1	−	−
Example 52	−	−	−	−
Example 53	−	−	81.3	<1
Example 54	80.6	<1	−	−
Example 55	−	−	−	−
Example 56	−	−	76.9	<1

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Table 11 (continued)

Examples	Properties of transparent coloring composition (I)			
	Transmittance (B)		Transmittance (Y)	
	460 nm (%)	610 nm (%)	550 nm (%)	400 nm (%)
Example 38	78.9	<1	–	–
Example 39	–	–	–	–
Example 40	–	–	–	–
Example 41	–	–	–	–
Example 42	–	–	80.0	<1
Example 43	81.3	<1	–	–
Example 44	–	–	–	–
Example 45	–	–	–	–
Example 46	83.2	<1	–	–
Example 47	–	–	–	–
Example 48	–	–	–	–
Example 49	76.8	<1	–	–
Example 50	–	–	–	–
Example 51	–	–	–	–
Example 52	81.2	<1	–	–
Example 53	–	–	–	–
Example 54	–	–	–	–
Example 55	79.6	<1	–	–
Example 56	–	–	–	–

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Table 11 (continued)

Examples	Properties of transparent coloring composition (I)			
	Specific absorptivity (based on weight)			
	550 nm ε_w (-)	650 nm ε_w (-)	610 nm ε_w (-)	400 nm ε_w (-)
Example 38	–	–	2.12	–
Example 39	–	2.24	–	–
Example 40	2.06	–	–	–
Example 41	1.87	–	–	–
Example 42	–	–	–	2.05
Example 43	–	–	1.68	–
Example 44	–	1.73	–	–
Example 45	1.86	–	–	–
Example 46	–	–	2.05	–
Example 47	–	2.08	–	–
Example 48	2.03	–	–	–
Example 49	–	–	1.68	–
Example 50	–	1.70	–	–
Example 51	1.67	–	–	–
Example 52	–	–	2.08	–
Example 53	–	2.04	–	–
Example 54	2.03	–	–	–
Example 55	–	–	2.24	–
Example 56	–	2.35	–	–

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Table 12

Comparative Examples and Reference Examples	Properties of transparent coloring composition (I)		
	Viscosity (mPa·s)	Dispersion average particle diameter (Dd_{50}) (nm)	Dispersion particle diameter (Dd_{84}) (nm)
Comparative Example 7	368	463	1463
Comparative Example 8	542	582	2252
Comparative Example 9	1163	678	2685
Comparative Example 10	683	376	1075
Comparative Example 11	876	369	1085
Comparative Example 12	2303	386	1112
Comparative Example 13	462	268	516
Comparative Example 14	662	276	553
Comparative Example 15	862	264	589
Reference Example 4	56.8	338	856
Reference Example 5	61.3	346	872
Reference Example 6	73.2	364	935

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Table 12 (continued)

Comparative Examples and Reference Examples	Properties of transparent coloring composition (I)	
	Dispersion maximum particle diameter (Dd_{99}) (nm)	Geometrical standard deviation (Dd_{84}/Dd_{50}) (-)
Comparative Example 7	2063	3.16
Comparative Example 8	2682	3.87
Comparative Example 9	3162	3.96
Comparative Example 10	1623	2.86
Comparative Example 11	1462	2.94
Comparative Example 12	1566	2.88
Comparative Example 13	962	1.93
Comparative Example 14	968	2.00
Comparative Example 15	912	2.23
Reference Example 4	1163	2.53
Reference Example 5	1187	2.52
Reference Example 6	1213	2.57

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Table 12 (continued)

Examples	Properties of colored transparent film (II)					
	Transmittance (R)		Transmittance (G)		Transmittance (B)	
	620 nm (%)	550 nm (%)	530 nm (%)	650 nm (%)	460 nm (%)	610 nm (%)
Comparative Example 7	-	-	-	-	63.3	5.6
Comparative Example 8	-	-	56.2	5.1	-	-
Comparative Example 9	48.3	5.6	-	-	-	-
Comparative Example 10	-	-	-	-	62.6	6.1
Comparative Example 11	-	-	51.3	5.2	-	-
Comparative Example 12	46.8	6.3	-	-	-	-
Comparative Example 13	-	-	-	-	31.6	3.4
Comparative Example 14	-	-	32.6	3.6	-	-
Comparative Example 15	30.8	3.1	-	-	-	-
Reference Example 4	-	-	-	-	68.6	1.3
Reference Example 5	-	-	69.3	1.4	-	-
Reference Example 6	64.4	3.1	-	-	-	-

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Table 12 (continued)

Comparative Examples and Reference Examples	Properties of transparent coloring composition (I)		
	Specific absorptivity (based on weight)		
	550 nm ε_w (-)	650 nm ε_w (-)	610 nm ε_w (-)
Comparative Example 7	-	-	1.00
Comparative Example 8	-	1.00	-
Comparative Example 9	1.00	-	-
Comparative Example 10	-	-	1.02
Comparative Example 11	-	1.01	-
Comparative Example 12	1.04	-	-
Comparative Example 13	-	-	1.12
Comparative Example 14	-	1.15	-
Comparative Example 15	1.08	-	-
Reference Example 4	-	-	1.67
Reference Example 5	-	1.71	-
Reference Example 6	1.59	-	-

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Table 13

Examples	Production of transparent coloring composition (II)	
	Transparent coloring composition (I)	
	Kind	Amount blended (wt. part)
Example 57	Example 38	400.0
Example 58	Example 39	400.0
Example 59	Example 40	400.0
Example 60	Example 41	390.0
Example 61	Example 42	420.0
Example 62	Example 43	420.0
Example 63	Example 44	420.0
Example 64	Example 45	420.0
Example 65	Example 46	380.0
Example 66	Example 47	380.0
Example 67	Example 48	380.0
Example 68	Example 49	420.0
Example 69	Example 50	420.0
Example 70	Example 51	420.0
Example 71	Example 52	390.0
Example 72	Example 53	390.0
Example 73	Example 54	390.0
Example 74	Example 55	440.0
Example 75	Example 56	400.0

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Table 13 (continued)

Examples	Production of transparent coloring composition (II)	
	Resin	
	Kind	Amount blended (wt. part)
Example 57	MM/MA copolymer*	100.0
Example 58	MM/MA copolymer*	100.0
Example 59	MM/MA copolymer*	100.0
Example 60	MM/MA copolymer*	90.0
Example 61	MM/MA copolymer*	80.0
Example 62	MM/MA copolymer*	100.0
Example 63	MM/MA copolymer*	100.0
Example 64	MM/MA copolymer*	100.0
Example 65	MM/MA copolymer*	80.0
Example 66	MM/MA copolymer*	80.0
Example 67	MM/MA copolymer*	80.0
Example 68	MM/MA copolymer*	90.0
Example 69	MM/MA copolymer*	90.0
Example 70	MM/MA copolymer*	90.0
Example 71	MM/MA copolymer*	100.0
Example 72	MM/MA copolymer*	100.0
Example 73	MM/MA copolymer*	100.0
Example 74	MM/MA copolymer*	80.0
Example 75	MM/MA copolymer*	90.0

Note: * Methyl methacrylate/methacrylic acid copolymer

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Table 14

Comparative Examples and Reference Examples	Production of transparent coloring composition (II)	
	Transparent coloring composition (I)	
	Kind	Amount blended (wt. part)
Comparative Example 16	Comparative Example 7	400.0
Comparative Example 17	Comparative Example 8	400.0
Comparative Example 18	Comparative Example 9	400.0
Comparative Example 19	Comparative Example 10	400.0
Comparative Example 20	Comparative Example 11	400.0
Comparative Example 21	Comparative Example 12	400.0
Comparative Example 22	Comparative Example 13	400.0
Comparative Example 23	Comparative Example 14	400.0
Comparative Example 24	Comparative Example 15	400.0
Reference Example 7	Reference Example 4	400.0
Reference Example 8	Reference Example 5	400.0
Reference Example 9	Reference Example 6	400.0

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Table 14 (continued)

Comparative Examples and Reference Examples	Production of transparent coloring composition (II)	
	Resin	
	Kind	Amount blended (wt. part)
Comparative Example 16	Methyl methacrylate/methacrylic acid copolymer	100.0
Comparative Example 17	Methyl methacrylate/methacrylic acid copolymer	100.0
Comparative Example 18	Methyl methacrylate/methacrylic acid copolymer	100.0
Comparative Example 19	Methyl methacrylate/methacrylic acid copolymer	100.0
Comparative Example 20	Methyl methacrylate/methacrylic acid copolymer	100.0
Comparative Example 21	Methyl methacrylate/methacrylic acid copolymer	100.0
Comparative Example 22	Methyl methacrylate/methacrylic acid copolymer	100.0
Comparative Example 23	Methyl methacrylate/methacrylic acid copolymer	100.0
Comparative Example 24	Methyl methacrylate/methacrylic acid copolymer	100.0
Reference Example 7	Methyl methacrylate/methacrylic acid copolymer	100.0
Reference Example 8	Methyl methacrylate/methacrylic acid copolymer	100.0
Reference Example 9	Methyl methacrylate/methacrylic acid copolymer	100.0

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Table 15

Examples	Properties of transparent coloring composition (II)		
	Viscosity (mPa·s)	Dispersion average particle diameter (Dd$_{50}$) (nm)	Dispersion particle diameter (Dd$_{84}$) (nm)
Example 57	21.3	66	117
Example 58	16.8	77	136
Example 59	31.3	87	142
Example 60	26.8	43	61
Example 61	31.7	21	34
Example 62	25.2	24	45
Example 63	16.8	43	75
Example 64	32.4	56	104
Example 65	48.6	54	91
Example 66	21.7	43	75
Example 67	30.0	64	99
Example 68	20.6	67	92
Example 69	54.6	21	37
Example 70	34.4	45	70
Example 71	43.2	65	109
Example 72	51.6	56	82
Example 73	56.3	51	80
Example 74	32.7	37	58
Example 75	37.6	48	81

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Table 15 (continued)

Examples	Properties of transparent coloring composition (II)	
	Dispersion maximum particle diameter (Dd_{99}) (nm)	Geometrical standard deviation (Dd_{84}/Dd_{50}) (-)
Example 57	156	1.77
Example 58	186	1.76
Example 59	184	1.63
Example 60	108	1.43
Example 61	68	1.60
Example 62	87	1.86
Example 63	101	1.74
Example 64	146	1.86
Example 65	147	1.68
Example 66	136	1.75
Example 67	150	1.55
Example 68	144	1.38
Example 69	68	1.76
Example 70	124	1.56
Example 71	152	1.67
Example 72	137	1.46
Example 73	126	1.56
Example 74	109	1.58
Example 75	149	1.68

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Table 15 (continued)

Examples	Properties of transparent coloring composition (II)			
	Specific absorptivity (based on weight)			
	550 nm ε_w (-)	650 nm ε_w (-)	610 nm ε_w (-)	400 nm ε_w (-)
Example 57	-	-	2.24	-
Example 58	-	2.28	-	-
Example 59	2.11	-	-	-
Example 60	1.92	-	-	-
Example 61	-	-	-	2.09
Example 62	-	-	1.74	-
Example 63	-	1.78	-	-
Example 64	1.91	-	-	-
Example 65	-	-	2.11	-
Example 66	-	2.13	-	-
Example 67	2.09	-	-	-
Example 68	-	-	1.74	-
Example 69	-	1.75	-	-
Example 70	1.73	-	-	-
Example 71	-	-	2.12	-
Example 72	-	2.08	-	-
Example 73	2.09	-	-	-
Example 74	-	-	2.28	-
Example 75	-	2.36	-	-

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Table 16

Comparative Examples and Reference Examples	Properties of transparent coloring composition (II)		
	Viscosity (mPa·s)	Dispersion average particle diameter (Dd_{50}) (nm)	Dispersion particle diameter (Dd_{84}) (nm)
Comparative Example 16	286	388	1117
Comparative Example 17	367	564	1771
Comparative Example 18	765	578	2058
Comparative Example 19	546	366	977
Comparative Example 20	458	335	965
Comparative Example 21	1368	324	930
Comparative Example 22	358	262	499
Comparative Example 23	568	283	492
Comparative Example 24	658	271	506
Reference Example 7	51.5	345	872
Reference Example 8	65.7	334	839
Reference Example 9	67.9	359	922

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Table 16 (continued)

Comparative Examples and Reference Examples	Properties of transparent coloring composition (II)	
	Dispersion maximum particle diameter (Dd_{99}) (nm)	Geometrical standard deviation (Dd_{84}/Dd_{50}) (-)
Comparative Example 16	1457	2.88
Comparative Example 17	2234	3.14
Comparative Example 18	2546	3.56
Comparative Example 19	1453	2.67
Comparative Example 20	1357	2.88
Comparative Example 21	1375	2.87
Comparative Example 22	1123	1.90
Comparative Example 23	1087	1.74
Comparative Example 24	1232	1.87
Reference Example 7	1078	2.53
Reference Example 8	1059	2.51
Reference Example 9	1109	2.57

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Table 16 (continued)

Comparative Examples and Reference Examples	Properties of transparent coloring composition (II)			
	Specific absorptivity (based on weight)			
	550 nm ε_w (−)	650 nm ε_w (−)	610 nm ε_w (−)	400 nm ε_w (−)
Comparative Example 16	−	−	1.00	−
Comparative Example 17	−	1.00	−	−
Comparative Example 18	1.00	−	−	−
Comparative Example 19	−	−	1.02	−
Comparative Example 20	−	1.03	−	−
Comparative Example 21	1.03	−	−	−
Comparative Example 22	−	−	1.11	−
Comparative Example 23	−	1.18	−	−
Comparative Example 24	1.13	−	−	−
Reference Example 7	−	−	1.69	−
Reference Example 8	−	1.74	−	−
Reference Example 9	1.63	−	−	−

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Table 17

Examples	Properties of colored transparent film (II)				
	Surface roughness Ra (nm)	Chromaticity			Photofatigue resistance ΔE* value (-)
		x (-)	y (-)	Y (-)	
Example 57	6.0	0.1477	0.2194	29.37	2.86
Example 58	5.8	0.2746	0.3882	70.27	2.68
Example 59	7.3	0.5672	0.3186	22.72	3.72
Example 60	6.4	0.5761	0.3226	23.16	3.56
Example 61	5.2	0.1337	0.2063	31.28	2.16
Example 62	6.8	0.1468	0.2168	30.64	1.84
Example 63	7.2	0.2749	0.3876	70.61	2.12
Example 64	6.5	0.5832	0.3386	24.16	1.96
Example 65	4.8	0.1567	0.2326	30.07	1.83
Example 66	6.3	0.2664	0.3896	71.32	2.01
Example 67	7.1	0.5763	0.3412	23.83	2.11
Example 68	6.8	0.1538	0.2269	28.64	2.34
Example 69	6.8	0.2668	0.3763	70.68	1.68
Example 70	6.5	0.5836	0.3120	24.66	2.00
Example 71	6.3	0.1668	0.2312	29.96	1.96
Example 72	5.6	0.2732	0.3889	71.32	1.84
Example 73	6.1	0.5673	0.3284	22.86	1.76
Example 74	5.9	0.1664	0.2445	32.16	1.73
Example 75	5.8	0.2668	0.3962	72.13	1.64

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Table 17 (continued)

Examples	Properties of colored transparent film (II)			
	Transmittance (R)		Transmittance (G)	
	620 nm (%)	550 nm (%)	530 nm (%)	650 nm (%)
Example 57	−	−	−	−
Example 58	−	−	92.3	<1
Example 59	94.6	<1	−	−
Example 60	91.3	<1	−	−
Example 61	−	−	−	−
Example 62	−	−	−	−
Example 63	−	−	94.1	<1
Example 64	95.6	<1	−	−
Example 65	−	−	−	−
Example 66	−	−	94.6	<1
Example 67	91.3	<1	−	−
Example 68	−	−	−	−
Example 69	−	−	93.6	<1
Example 70	91.2	<1	−	−
Example 71	−	−	−	−
Example 72	−	−	91.3	<1
Example 73	92.6	<1	−	−
Example 74	−	−	−	−
Example 75	−	−	93.3	<1

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Table 17 (continued)

Examples	Properties of colored transparent film (II)			
	Transmittance (B)		Transmittance (Y)	
	460 nm (%)	610 nm (%)	550 nm (%)	400 nm (%)
Example 57	92.1	<1	–	–
Example 58	–	–	–	–
Example 59	–	–	–	–
Example 60	–	–	–	–
Example 61	–	–	91.2	<1
Example 62	93.6	<1	–	–
Example 63	–	–	–	–
Example 64	–	–	–	–
Example 65	95.8	<1	–	–
Example 66	–	–	–	–
Example 67	–	–	–	–
Example 68	94.1	<1	–	–
Example 69	–	–	–	–
Example 70	–	–	–	–
Example 71	91.6	<1	–	–
Example 72	–	–	–	–
Example 73	–	–	–	–
Example 74	94.5	<1	–	–
Example 75	–	–	–	–

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Table 18

Comparative Examples and Reference Examples	Properties of colored transparent film (II)				
	Surface roughness Ra (nm)	Chromaticity			Photofatigue resistance ΔE* value (-)
		x (-)	y (-)	Y (-)	
Comparative Example 16	38.6	0.1603	0.2246	26.53	8.13
Comparative Example 17	36.2	0.2722	0.3763	64.62	7.96
Comparative Example 18	28.1	0.5338	0.3018	21.63	10.13
Comparative Example 19	46.3	0.1556	0.2316	25.42	7.14
Comparative Example 20	51.6	0.2816	0.3862	65.12	6.64
Comparative Example 21	63.2	0.5264	0.3123	21.56	8.13
Comparative Example 22	26.6	0.1558	0.2113	23.66	5.48
Comparative Example 23	27.2	0.2716	0.3872	65.96	5.36
Comparative Example 24	25.8	0.5362	0.3226	22.63	5.28
Reference Example 7	12.3	0.1613	0.2326	24.13	1.98
Reference Example 8	13.5	0.2688	0.3886	64.12	1.72
Reference Example 9	14.2	0.5216	0.3063	20.16	2.13

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Table 18 (continued)

Comparative Examples and Reference Examples	Properties of colored transparent film (II)					
	Transmittance (R)		Transmittance (G)		Transmittance (B)	
	620 nm (%)	550 nm (%)	530 nm (%)	650 nm (%)	460 nm (%)	610 nm (%)
Comparative Example 16	–	–	–	–	73.3	6.6
Comparative Example 17	–	–	74.2	6.1	–	–
Comparative Example 18	71.5	5.6	–	–	–	–
Comparative Example 19	–	–	–	–	69.7	6.5
Comparative Example 20	–	–	71.3	6.2	–	–
Comparative Example 21	66.8	6.3	–	–	–	–
Comparative Example 22	–	–	–	–	33.4	3.5
Comparative Example 23	–	–	35.9	3.3	–	–
Comparative Example 24	31.1	3.1	–	–	–	–
Reference Example 7	–	–	–	–	76.3	<1
Reference Example 8	–	–	78.9	<1	–	–
Reference Example 9	74.4	<1	–	–	–	–

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Table 19

Examples	Production of transparent coloring composition (III)	
	Transparent coloring composition (II)	
	Kind	Amount blended (wt. part)
Example 76	Example 57	500.0
Example 77	Example 58	500.0
Example 78	Example 59	500.0
Example 79	Example 60	480.0
Example 80	Example 61	500.0
Example 81	Example 62	520.0
Example 82	Example 63	520.0
Example 83	Example 64	520.0
Example 84	Example 65	460.0
Example 85	Example 66	460.0
Example 86	Example 67	460.0
Example 87	Example 68	510.0
Example 88	Example 69	510.0
Example 89	Example 70	510.0
Example 90	Example 71	490.0
Example 91	Example 72	490.0
Example 92	Example 73	490.0
Example 93	Example 74	520.0
Example 94	Example 75	490.0

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Table 19 (continued)

| Examples | Production of transparent coloring composition (III) | |
| | Polyfunctional monomer | |
	Kind	Amount blended (wt. part)
Example 76	Dipentaerythritol pentaacrylate	100.0
Example 77	Dipentaerythritol pentaacrylate	100.0
Example 78	Dipentaerythritol pentaacrylate	100.0
Example 79	Dipentaerythritol pentaacrylate	100.0
Example 80	Dipentaerythritol pentaacrylate	100.0
Example 81	Dipentaerythritol pentaacrylate	100.0
Example 82	Dipentaerythritol pentaacrylate	100.0
Example 83	Dipentaerythritol pentaacrylate	100.0
Example 84	Dipentaerythritol pentaacrylate	100.0
Example 85	Dipentaerythritol pentaacrylate	100.0
Example 86	Dipentaerythritol pentaacrylate	100.0
Example 87	Dipentaerythritol pentaacrylate	100.0
Example 88	Dipentaerythritol pentaacrylate	100.0
Example 89	Dipentaerythritol pentaacrylate	100.0
Example 90	Dipentaerythritol pentaacrylate	100.0
Example 91	Dipentaerythritol pentaacrylate	100.0
Example 92	Dipentaerythritol pentaacrylate	100.0
Example 93	Dipentaerythritol pentaacrylate	100.0
Example 94	Dipentaerythritol pentaacrylate	100.0

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Table 19 (continued)

Examples	Production of transparent coloring composition (III)	
	Polymerization initiator	
	Kind	Amount blended (wt. part)
Example 76	Triazine-based compound**	5.0
Example 77	Triazine-based compound**	5.0
Example 78	Triazine-based compound**	5.0
Example 79	Triazine-based compound**	4.5
Example 80	Triazine-based compound**	3.5
Example 81	Triazine-based compound**	2.5
Example 82	Triazine-based compound**	2.5
Example 83	Triazine-based compound**	2.5
Example 84	Triazine-based compound**	3.0
Example 85	Triazine-based compound**	3.0
Example 86	Triazine-based compound**	3.0
Example 87	Triazine-based compound**	4.5
Example 88	Triazine-based compound**	4.5
Example 89	Triazine-based compound**	4.5
Example 90	Triazine-based compound**	4.0
Example 91	Triazine-based compound**	4.0
Example 92	Triazine-based compound**	4.0
Example 93	Triazine-based compound**	4.0
Example 94	Triazine-based compound**	4.5

Note: ** 2-(4-methoxy-β-styryl)-bis(4,6-trichloromethyl)-s-triazine

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Table 20

Comparative Examples and Reference Examples	Production of transparent coloring composition (III)	
	Transparent coloring composition (II)	
	Kind	Amount blended (wt. part)
Comparative Example 25	Comparative Example 16	500.0
Comparative Example 26	Comparative Example 17	500.0
Comparative Example 27	Comparative Example 18	500.0
Comparative Example 28	Comparative Example 19	500.0
Comparative Example 29	Comparative Example 20	500.0
Comparative Example 30	Comparative Example 21	500.0
Comparative Example 31	Comparative Example 22	500.0
Comparative Example 32	Comparative Example 23	500.0
Comparative Example 33	Comparative Example 24	500.0
Reference Example 10	Reference Example 7	500.0
Reference Example 11	Reference Example 8	500.0
Reference Example 12	Reference Example 9	500.0

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Table 20 (continued)

Comparative Examples and Reference Examples	Production of transparent coloring composition (III)	
	Polyfunctional monomer	
	Kind	Amount blended (wt. part)
Comparative Example 25	Dipentaerythritol pentaacrylate	100.0
Comparative Example 26	Dipentaerythritol pentaacrylate	100.0
Comparative Example 27	Dipentaerythritol pentaacrylate	100.0
Comparative Example 28	Dipentaerythritol pentaacrylate	100.0
Comparative Example 29	Dipentaerythritol pentaacrylate	100.0
Comparative Example 30	Dipentaerythritol pentaacrylate	100.0
Comparative Example 31	Dipentaerythritol pentaacrylate	100.0
Comparative Example 32	Dipentaerythritol pentaacrylate	100.0
Comparative Example 33	Dipentaerythritol pentaacrylate	100.0
Reference Example 10	Dipentaerythritol pentaacrylate	100.0
Reference Example 11	Dipentaerythritol pentaacrylate	100.0
Reference Example 12	Dipentaerythritol pentaacrylate	100.0

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Table 20 (continued)

Comparative Examples and Reference Examples	Production of transparent coloring composition (III)	
	Polymerization initiator	
	Kind	Amount blended (wt. part)
Comparative Example 25	Triazine-based compound**	5.0
Comparative Example 26	Triazine-based compound**	5.0
Comparative Example 27	Triazine-based compound**	5.0
Comparative Example 28	Triazine-based compound**	5.0
Comparative Example 29	Triazine-based compound**	5.0
Comparative Example 30	Triazine-based compound**	5.0
Comparative Example 31	Triazine-based compound**	5.0
Comparative Example 32	Triazine-based compound**	5.0
Comparative Example 33	Triazine-based compound**	5.0
Reference Example 10	Triazine-based compound**	5.0
Reference Example 11	Triazine-based compound**	5.0
Reference Example 12	Triazine-based compound**	5.0

Note: ** 2-(4-methoxy-β-styryl)-bis(4,6-trichloromethyl)-s-triazine

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Table 21

Examples	Properties of transparent coloring composition (III)		
	Viscosity (mPa·s)	Dispersion average particle diameter (Dd_{50}) (nm)	Dispersion particle diameter (Dd_{84}) (nm)
Example 76	18.9	56	94
Example 77	17.8	67	115
Example 78	30.2	78	129
Example 79	26.7	46	67
Example 80	28.8	18	30
Example 81	26.8	23	41
Example 82	21.8	36	60
Example 83	28.6	46	81
Example 84	34.3	55	91
Example 85	19.7	36	62
Example 86	26.7	57	88
Example 87	22.2	46	62
Example 88	38.6	22	37
Example 89	27.9	35	56
Example 90	37.7	38	63
Example 91	37.2	45	65
Example 92	39.9	38	55
Example 93	34.5	32	50
Example 94	33.3	28	45

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Table 21 (continued)

Examples	Properties of transparent coloring composition (III)	
	Dispersion maximum particle diameter (Dd_{99}) (nm)	Geometrical standard deviation (Dd_{84}/Dd_{50}) (-)
Example 76	144	1.68
Example 77	156	1.71
Example 78	167	1.66
Example 79	135	1.45
Example 80	55	1.68
Example 81	68	1.78
Example 82	88	1.68
Example 83	112	1.77
Example 84	132	1.65
Example 85	110	1.71
Example 86	126	1.54
Example 87	132	1.35
Example 88	77	1.68
Example 89	89	1.61
Example 90	99	1.67
Example 91	103	1.45
Example 92	98	1.46
Example 93	75	1.56
Example 94	69	1.59

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Table 21 (continued)

Examples	Properties of transparent coloring composition (III)			
	Specific absorptivity (based on weight)			
	550 nm ε_w (-)	650 nm ε_w (-)	610 nm ε_w (-)	400 nm ε_w (-)
Example 76	-	-	2.23	-
Example 77	-	2.29	-	-
Example 78	2.10	-	-	-
Example 79	1.93	-	-	-
Example 80	-	-	-	2.08
Example 81	-	-	1.73	-
Example 82	-	1.79	-	-
Example 83	1.90	-	-	-
Example 84	-	-	2.10	-
Example 85	-	2.12	-	-
Example 86	2.10	-	-	-
Example 87	-	-	1.75	-
Example 88	-	1.76	-	-
Example 89	1.73	-	-	-
Example 90	-	-	2.12	-
Example 91	-	2.09	-	-
Example 92	2.08	-	-	-
Example 93	-	-	2.27	-
Example 94	-	2.35	-	-

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Table 22

Comparative Examples and Reference Examples	Properties of transparent coloring composition (III)		
	Viscosity (mPa·s)	Dispersion average particle diameter (Dd_{50}) (nm)	Dispersion particle diameter (Dd_{84}) (nm)
Comparative Example 25	226	322	824
Comparative Example 26	356	467	1289
Comparative Example 27	678	452	1257
Comparative Example 28	468	321	822
Comparative Example 29	358	289	772
Comparative Example 30	980	298	855
Comparative Example 31	288	275	526
Comparative Example 32	453	269	569
Comparative Example 33	564	284	519
Reference Example 10	65.9	356	894
Reference Example 11	52.4	348	887
Reference Example 12	64.9	366	921

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Table 22 (continued)

Comparative Examples and Reference Examples	Properties of transparent coloring composition (III)	
	Dispersion maximum particle diameter (Dd_{99}) (nm)	Geometrical standard deviation (Dd_{84}/Dd_{50}) $(-)$
Comparative Example 25	1234	2.56
Comparative Example 26	1867	2.76
Comparative Example 27	1926	2.78
Comparative Example 28	1595	2.56
Comparative Example 29	1368	2.67
Comparative Example 30	1415	2.87
Comparative Example 31	932	1.91
Comparative Example 32	962	2.12
Comparative Example 33	949	1.83
Reference Example 10	1056	2.51
Reference Example 11	1090	2.55
Reference Example 12	1069	2.52

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Table 22 (continued)

Comparative Examples and Reference Examples	Properties of transparent coloring composition (III)			
	Specific absorptivity (based on weight)			
	550 nm ε_w (−)	650 nm ε_w (−)	610 nm ε_w (−)	400 nm ε_w (−)
Comparative Example 25	−	−	1.00	−
Comparative Example 26	−	1.00	−	−
Comparative Example 27	1.00	−	−	−
Comparative Example 28	−	−	1.02	−
Comparative Example 29	−	1.04	−	−
Comparative Example 30	1.01	−	−	−
Comparative Example 31	−	−	1.10	−
Comparative Example 32	−	1.17	−	−
Comparative Example 33	1.12	−	−	−
Reference Example 10	−	−	1.70	−
Reference Example 11	−	1.73	−	−
Reference Example 12	1.61	−	−	−

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Table 23

Examples	Properties of colored transparent film (III)				
	Surface roughness Ra (nm)	Chromaticity			Photofatigue resistance ΔE* value (−)
		x (−)	y (−)	Y (−)	
Example 76	5.0	0.1487	0.2186	29.54	2.83
Example 77	4.8	0.2735	0.3877	70.57	2.65
Example 78	6.2	0.5665	0.3154	23.02	3.70
Example 79	5.3	0.5772	0.3239	23.39	3.52
Example 80	4.6	0.1342	0.2078	31.48	2.10
Example 81	5.3	0.1471	0.2155	30.99	1.78
Example 82	6.0	0.2735	0.3834	70.59	2.01
Example 83	5.3	0.5833	0.3343	24.58	1.84
Example 84	3.9	0.1569	0.2352	30.87	1.68
Example 85	5.3	0.2653	0.3848	71.66	1.89
Example 86	5.9	0.5736	0.3424	23.99	1.95
Example 87	5.8	0.1564	0.2232	28.79	2.11
Example 88	5.8	0.2689	0.3778	70.98	1.54
Example 89	5.4	0.5821	0.3159	24.96	1.78
Example 90	4.7	0.1646	0.2303	30.33	1.84
Example 91	4.5	0.2716	0.3890	71.76	1.78
Example 92	5.3	0.5636	0.3254	23.00	1.76
Example 93	5.0	0.1698	0.2447	32.67	1.68
Example 94	5.0	0.2640	0.3947	72.46	1.61

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Table 23 (continued)

Examples	Properties of colored transparent film (III)			
	Transmittance (R)		Transmittance (G)	
	620 nm (%)	550 nm (%)	530 nm (%)	650 nm (%)
Example 76	–	–	–	–
Example 77	–	–	93.3	<1
Example 78	95.1	<1	–	–
Example 79	92.2	<1	–	–
Example 80	–	–	–	–
Example 81	–	–	–	–
Example 82	–	–	94.5	<1
Example 83	96.6	<1	–	–
Example 84	–	–	–	–
Example 85	–	–	94.9	<1
Example 86	93.3	<1	–	–
Example 87	–	–	–	–
Example 88	–	–	93.9	<1
Example 89	93.2	<1	–	–
Example 90	–	–	–	–
Example 91	–	–	91.9	<1
Example 92	94.1	<1	–	–
Example 93	–	–	–	–
Example 94	–	–	93.6	<1

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Table 23 (continued)

Examples	Properties of colored transparent film (III)			
	Transmittance (B)		Transmittance (Y)	
	460 nm (%)	610 nm (%)	550 nm (%)	400 nm (%)
Example 76	92.7	<1	–	–
Example 77	–	–	–	–
Example 78	–	–	–	–
Example 79	–	–	–	–
Example 80	–	–	92.3	<1
Example 81	93.9	<1	–	–
Example 82	–	–	–	–
Example 83	–	–	–	–
Example 84	95.7	<1	–	–
Example 85	–	–	–	–
Example 86	–	–	–	–
Example 87	94.3	<1	–	–
Example 88	–	–	–	–
Example 89	–	–	–	–
Example 90	91.2	<1	–	–
Example 91	–	–	–	–
Example 92	–	–	–	–
Example 93	94.7	<1	–	–
Example 94	–	–	–	–

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Table 24

Comparative Examples and Reference Examples	Properties of colored transparent film (III)				
	Surface roughness Ra (nm)	Chromaticity			Photofatigue resistance ΔE* value (-)
		x (-)	y (-)	Y (-)	
Comparative Example 25	38.2	0.1600	0.2221	26.26	8.01
Comparative Example 26	35.8	0.2721	0.3756	64.58	7.88
Comparative Example 27	27.2	0.5333	0.3015	21.99	10.56
Comparative Example 28	43.2	0.1563	0.2319	25.65	7.27
Comparative Example 29	48.3	0.2824	0.3855	65.16	6.32
Comparative Example 30	55.6	0.5277	0.3148	21.61	7.88
Comparative Example 31	22.1	0.1563	0.2156	23.70	5.89
Comparative Example 32	28.3	0.2745	0.3836	65.88	5.87
Comparative Example 33	24.3	0.5323	0.3252	22.72	5.26
Reference Example 10	18.0	0.1628	0.2388	24.55	1.84
Reference Example 11	16.0	0.2656	0.3878	64.26	1.74
Reference Example 12	16.8	0.5211	0.3032	20.33	1.99

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Table 24 (continued)

Comparative Examples and Reference Examples	Properties of colored transparent film (III)					
	Transmittance (R)		Transmittance (G)		Transmittance (B)	
	620 nm (%)	550 nm (%)	530 nm (%)	650 nm (%)	460 nm (%)	610 nm (%)
Comparative Example 25	−	−	−	−	72.4	6.7
Comparative Example 26	−	−	73.1	6.0	−	−
Comparative Example 27	71.6	5.4	−	−	−	−
Comparative Example 28	−	−	−	−	68.9	2.0
Comparative Example 29	−	−	70.5	2.8	−	−
Comparative Example 30	65.7	6.5	−	−	−	−
Comparative Example 31	−	−	−	−	34.8	3.3
Comparative Example 32	−	−	36.6	3.2	−	−
Comparative Example 33	32.3	2.9	−	−	−	−
Reference Example 10	−	−	−	−	75.1	<1
Reference Example 11	−	−	77.2	<1	−	−
Reference Example 12	73.4	<1	−	−	−	−

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Table 25

Examples	Production of transparent coloring composition (IV)	
	Transparent coloring composition (II)	
	Kind	Amount blended (wt. part)
Example 95	Example 57	500.0
Example 96	Example 58	500.0
Example 97	Example 59	500.0
Example 98	Example 60	480.0
Example 99	Example 61	500.0
Example 100	Example 62	520.0
Example 101	Example 63	520.0
Example 102	Example 64	520.0
Example 103	Example 65	460.0
Example 104	Example 66	460.0
Example 105	Example 67	460.0
Example 106	Example 68	510.0
Example 107	Example 69	510.0
Example 108	Example 70	510.0
Example 109	Example 71	490.0
Example 110	Example 72	490.0
Example 111	Example 73	490.0
Example 112	Example 74	520.0
Example 113	Example 75	490.0

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Table 25 (continued)

Examples	Production of transparent coloring composition (IV)	
	Photo-acid generator	
	Kind	Amount blended (wt. part)
Example 95	Onium salt compound***	5.0
Example 96	Onium salt compound***	5.0
Example 97	Onium salt compound***	5.0
Example 98	Onium salt compound***	4.5
Example 99	Onium salt compound***	3.5
Example 100	Halogen acid-generating compound****	2.5
Example 101	Halogen acid-generating compound****	2.5
Example 102	Halogen acid-generating compound****	2.5
Example 103	Halogen acid-generating compound****	3.0
Example 104	Halogen acid-generating compound****	3.0
Example 105	Halogen acid-generating compound****	3.0
Example 106	Sulfonic acid-generating compound*****	4.5
Example 107	Sulfonic acid-generating compound*****	4.5
Example 108	Sulfonic acid-generating compound*****	4.5
Example 109	Onium salt compound***	4.0
Example 110	Onium salt compound***	4.0
Example 111	Onium salt compound***	4.0
Example 112	Onium salt compound***	4.0
Example 113	Onium salt compound***	4.5

Note:
*** p-phenylthiophenyldiphenylsulfonium trifluoroacetate
**** 1-(3,4-dimethoxyphenyl)-3,5-bis(trichloromethyl)-s-triazine
***** N-trifluoromethanesulfonyloxydiphenylmaleimide

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Table 26

Comparative Examples and Reference Examples	Production of transparent coloring composition (IV)	
	Transparent coloring composition (II)	
	Kind	Amount blended (wt. part)
Comparative Example 34	Comparative Example 16	500.0
Comparative Example 35	Comparative Example 17	500.0
Comparative Example 36	Comparative Example 18	500.0
Comparative Example 37	Comparative Example 19	500.0
Comparative Example 38	Comparative Example 20	500.0
Comparative Example 39	Comparative Example 21	500.0
Comparative Example 40	Comparative Example 22	500.0
Comparative Example 41	Comparative Example 23	500.0
Comparative Example 42	Comparative Example 24	500.0
Reference Example 13	Reference Example 7	500.0
Reference Example 14	Reference Example 8	500.0
Reference Example 15	Reference Example 9	500.0

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Table 26 (continued)

Comparative Examples and Reference Examples	Production of transparent coloring composition (IV)	
	Photo-acid generator	
	Kind	Amount blended (wt. part)
Comparative Example 34	Onium salt compound***	5.0
Comparative Example 35	Onium salt compound***	5.0
Comparative Example 36	Onium salt compound***	5.0
Comparative Example 37	Onium salt compound***	5.0
Comparative Example 38	Onium salt compound***	5.0
Comparative Example 39	Onium salt compound***	5.0
Comparative Example 40	Onium salt compound***	5.0
Comparative Example 41	Onium salt compound***	5.0
Comparative Example 42	Onium salt compound***	5.0
Reference Example 13	Onium salt compound***	5.0
Reference Example 14	Onium salt compound***	5.0
Reference Example 15	Onium salt compound***	5.0

Note:
   *** p-phenylthiophenyldiphenylsulfonium trifluoroacetate

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Table 27

Examples	Properties of transparent coloring composition (IV)		
	Viscosity (mPa·s)	Dispersion average particle diameter (Dd_{50}) (nm)	Dispersion particle diameter (Dd_{84}) (nm)
Example 95	18.8	53	87
Example 96	16.8	68	119
Example 97	28.8	79	133
Example 98	24.6	48	70
Example 99	26.9	19	31
Example 100	24.9	25	43
Example 101	20.6	38	62
Example 102	25.6	49	85
Example 103	31.3	59	97
Example 104	19.9	41	71
Example 105	26.9	58	89
Example 106	22.8	49	66
Example 107	39.5	32	52
Example 108	30.8	28	46
Example 109	32.7	33	56
Example 110	33.8	40	59
Example 111	37.2	33	47
Example 112	30.7	37	57
Example 113	32.8	31	48

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Table 27 (continued)

Examples	Properties of transparent coloring composition (IV)	
	Dispersion maximum particle diameter (Dd_{99}) (nm)	Geometrical standard deviation (Dd_{84}/Dd_{50}) (-)
Example 95	145	1.65
Example 96	161	1.75
Example 97	169	1.68
Example 98	145	1.46
Example 99	65	1.63
Example 100	71	1.73
Example 101	93	1.63
Example 102	123	1.74
Example 103	146	1.65
Example 104	127	1.73
Example 105	143	1.53
Example 106	146	1.35
Example 107	80	1.62
Example 108	93	1.66
Example 109	103	1.69
Example 110	121	1.48
Example 111	105	1.43
Example 112	86	1.54
Example 113	76	1.55

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Table 27 (continued)

Examples	Properties of transparent coloring composition (IV)			
	Specific absorptivity (based on weight)			
	550 nm ε_w (-)	650 nm ε_w (-)	610 nm ε_w (-)	400 nm ε_w (-)
Example 95	-	-	2.22	-
Example 96	-	2.27	-	-
Example 97	2.11	-	-	-
Example 98	1.95	-	-	-
Example 99	-	-	-	2.09
Example 100	-	-	1.75	-
Example 101	-	1.78	-	-
Example 102	1.89	-	-	-
Example 103	-	-	2.11	-
Example 104	-	2.11	-	-
Example 105	2.11	-	-	-
Example 106	-	-	1.76	-
Example 107	-	1.75	-	-
Example 108	1.72	-	-	-
Example 109	-	-	2.11	-
Example 110	-	2.10	-	-
Example 111	2.09	-	-	-
Example 112	-	-	2.26	-
Example 113	-	2.34	-	-

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Table 28

Comparative Examples and Reference Examples	Properties of transparent coloring composition (IV)		
	Viscosity (mPa·s)	Dispersion average particle diameter (Dd_{50}) (nm)	Dispersion particle diameter (Dd_{84}) (nm)
Comparative Example 34	232	329	849
Comparative Example 35	412	471	1305
Comparative Example 36	587	463	1283
Comparative Example 37	421	333	862
Comparative Example 38	338	278	734
Comparative Example 39	678	286	795
Comparative Example 40	314	285	564
Comparative Example 41	333	271	507
Comparative Example 42	468	298	572
Reference Example 13	75.3	326	835
Reference Example 14	66.4	359	901
Reference Example 15	65.3	373	939

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Table 28 (continued)

Comparative Examples and Reference Examples	Properties of transparent coloring composition (IV)	
	Dispersion maximum particle diameter (Dd_{99}) (nm)	Geometrical standard deviation (Dd_{84}/Dd_{50}) (-)
Comparative Example 34	1223	2.58
Comparative Example 35	1500	2.77
Comparative Example 36	1789	2.77
Comparative Example 37	1521	2.59
Comparative Example 38	1432	2.64
Comparative Example 39	1639	2.78
Comparative Example 40	988	1.98
Comparative Example 41	867	1.87
Comparative Example 42	931	1.92
Reference Example 13	1112	2.56
Reference Example 14	1062	2.51
Reference Example 15	1078	2.52

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Table 28 (continued)

Comparative Examples and Reference Examples	Properties of transparent coloring composition (IV)			
	Specific absorptivity (based on weight)			
	550 nm ε_w (-)	650 nm ε_w (-)	610 nm ε_w (-)	400 nm ε_w (-)
Comparative Example 34	-	-	1.00	-
Comparative Example 35	-	1.00	-	-
Comparative Example 36	1.00	-	-	-
Comparative Example 37	-	-	1.02	-
Comparative Example 38	-	1.03	-	-
Comparative Example 39	1.02	-	-	-
Comparative Example 40	-	-	1.09	-
Comparative Example 41	-	1.16	-	-
Comparative Example 42	1.13	-	-	-
Reference Example 13	-	-	1.68	-
Reference Example 14	-	1.71	-	-
Reference Example 15	1.59	-	-	-

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Table 29

Examples	Properties of colored transparent film (IV)				
	Surface roughness Ra (nm)	Chromaticity			Photofatigue resistance ΔE* value (-)
		x (-)	y (-)	Y (-)	
Example 95	5.1	0.1483	0.2183	29.53	2.81
Example 96	4.7	0.2733	0.3873	70.51	2.63
Example 97	6.3	0.5661	0.3151	23.11	3.71
Example 98	5.5	0.5779	0.3234	23.41	3.54
Example 99	4.9	0.1342	0.2073	31.52	2.13
Example 100	5.9	0.1475	0.2152	30.87	1.79
Example 101	5.4	0.2732	0.3831	70.37	2.04
Example 102	5.9	0.5833	0.3347	24.58	1.86
Example 103	4.8	0.1563	0.2359	30.89	1.69
Example 104	5.6	0.2655	0.3843	71.47	1.84
Example 105	5.3	0.5738	0.3429	23.45	1.96
Example 106	5.2	0.1562	0.2235	28.53	2.14
Example 107	5.9	0.2682	0.3773	70.56	1.58
Example 108	5.8	0.5824	0.3154	24.87	1.73
Example 109	5.1	0.1646	0.2301	30.36	1.86
Example 110	5.3	0.2716	0.3893	71.77	1.73
Example 111	5.1	0.5638	0.3257	23.17	1.75
Example 112	5.8	0.1692	0.2449	32.64	1.64
Example 113	5.5	0.2643	0.3948	72.48	1.66

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Table 29 (continued)

Examples	Properties of colored transparent film (IV)			
	Transmittance (R)		Transmittance (G)	
	620 nm (%)	550 nm (%)	530 nm (%)	650 nm (%)
Example 95	–	–	–	–
Example 96	–	–	94.1	<1
Example 97	95.3	<1	–	–
Example 98	92.6	<1	–	–
Example 99	–	–	–	–
Example 100	–	–	–	–
Example 101	–	–	94.2	<1
Example 102	96.9	<1	–	–
Example 103	–	–	–	–
Example 104	–	–	94.0	<1
Example 105	93.9	<1	–	–
Example 106	–	–	–	–
Example 107	–	–	93.8	<1
Example 108	94.3	<1	–	–
Example 109	–	–	–	–
Example 110	–	–	91.3	<1
Example 111	94.5	<1	–	–
Example 112	–	–	–	–
Example 113	–	–	93.4	<1

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Table 29 (continued)

Examples	Properties of colored transparent film (IV)			
	Transmittance (B)		Transmittance (Y)	
	460 nm (%)	610 nm (%)	550 nm (%)	400 nm (%)
Example 95	92.4	<1	–	–
Example 96	–	–	–	–
Example 97	–	–	–	–
Example 98	–	–	–	–
Example 99	–	–	92.1	<1
Example 100	93.4	<1	–	–
Example 101	–	–	–	–
Example 102	–	–	–	–
Example 103	95.2	<1	–	–
Example 104	–	–	–	–
Example 105	–	–	–	–
Example 106	94.6	<1	–	–
Example 107	–	–	–	–
Example 108	–	–	–	–
Example 109	91.5	<1	–	–
Example 110	–	–	–	–
Example 111	–	–	–	–
Example 112	94.6	<1	–	–
Example 113	–	–	–	–

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Table 30

Comparative Examples and Reference Examples	Properties of colored transparent film (IV)				
	Surface roughness Ra (nm)	Chromaticity			Photofatigue resistance ΔE* value (-)
		x (-)	y (-)	Y (-)	
Comparative Example 34	36.3	0.1611	0.2236	26.27	7.87
Comparative Example 35	33.2	0.2724	0.3766	64.44	6.57
Comparative Example 36	38.2	0.5336	0.3081	21.67	8.65
Comparative Example 37	28.9	0.1543	0.2228	25.46	6.45
Comparative Example 38	38.0	0.2834	0.3864	65.19	5.78
Comparative Example 39	28.5	0.5228	0.3234	21.54	6.97
Comparative Example 40	28.5	0.1567	0.2222	23.67	5.21
Comparative Example 41	27.4	0.2727	0.3884	65.56	5.32
Comparative Example 42	22.6	0.5327	0.3247	22.83	5.36
Reference Example 13	12.2	0.1616	0.2323	24.64	1.97
Reference Example 14	13.4	0.2640	0.3845	64.48	1.88
Reference Example 15	14.1	0.5212	0.3028	20.46	2.15

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Table 30 (continued)

Comparative Examples and Reference Examples	Properties of colored transparent film (IV)					
	Transmittance (R)		Transmittance (G)		Transmittance (B)	
	620 nm (%)	550 nm (%)	530 nm (%)	650 nm (%)	460 nm (%)	610 nm (%)
Comparative Example 34	–	–	–	–	72.8	6.5
Comparative Example 35	–	–	73.3	5.8	–	–
Comparative Example 36	71.0	3.8	–	–	–	–
Comparative Example 37	–	–	–	–	69.2	6.6
Comparative Example 38	–	–	71.6	6.2	–	–
Comparative Example 39	67.5	5.1	–	–	–	–
Comparative Example 40	–	–	–	–	35.1	3.5
Comparative Example 41	–	–	36.7	2.9	–	–
Comparative Example 42	32.3	3.0	–	–	–	–
Reference Example 13	–	–	–	–	75.9	<1
Reference Example 14	–	–	76.7	<1	–	–
Reference Example 15	72.6	<1	–	–	–	–

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Table 31

Examples	Production of color filter			
	Method of producing color filter	Kind of colored transparent film		
		(R)	(G)	(B)
Example 114	Color filter (I)	Example 59	Example 58	Example 57
Example 115	Color filter (I)	Example 67	Example 66	Example 65
Example 116	Color filter (I)	Example 70	Example 69	Example 68
Example 117	Color filter (I)	Example 73	Example 72	Example 71
Example 118	Color filter (II)	Example 78	Example 77	Example 76
Example 119	Color filter (II)	Example 86	Example 85	Example 84
Example 120	Color filter (II)	Example 89	Example 88	Example 87
Example 121	Color filter (II)	Example 92	Example 91	Example 90
Example 122	Color filter (III)	Example 97	Example 96	Example 95
Example 123	Color filter (III)	Example 105	Example 104	Example 103
Example 124	Color filter (III)	Example 108	Example 107	Example 106
Example 125	Color filter (III)	Example 111	Example 110	Example 109

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Table 31 (continued)

Examples	Properties of color filter			
	Transmittance			Contrast (%)
	(R) (620 nm) (%)	(G) (530 nm) (%)	(B) (460 nm) (%)	
Example 114	94.6	92.3	92.1	1580
Example 115	91.3	94.6	95.8	1420
Example 116	91.2	93.6	94.1	1400
Example 117	92.6	91.3	91.6	1310
Example 118	95.1	93.3	92.7	1890
Example 119	93.3	94.9	95.7	1670
Example 120	93.2	93.9	94.3	1430
Example 121	94.1	91.9	91.2	1740
Example 122	95.3	94.1	92.4	2120
Example 123	93.9	94.0	95.2	1860
Example 124	94.3	93.8	94.6	1660
Example 125	94.5	91.3	91.5	1470

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Table 32

Comparative Examples and Reference Examples	Production of color filter			
	Method of producing color filter	Kind of colored transparent film		
		(R)	(G)	(B)
Comparative Example 43	Color filter (I)	Comparative Example 18	Comparative Example 17	Comparative Example 16
Comparative Example 44	Color filter (I)	Comparative Example 21	Comparative Example 20	Comparative Example 19
Comparative Example 45	Color filter (I)	Comparative Example 24	Comparative Example 23	Comparative Example 22
Reference Example 16	Color filter (I)	Reference Example 9	Reference Example 8	Reference Example 7
Comparative Example 46	Color filter (II)	Comparative Example 27	Comparative Example 26	Comparative Example 25
Comparative Example 47	Color filter (II)	Comparative Example 30	Comparative Example 29	Comparative Example 28
Comparative Example 48	Color filter (II)	Comparative Example 33	Comparative Example 32	Comparative Example 31
Reference Example 17	Color filter (II)	Reference Example 12	Reference Example 11	Reference Example 10
Comparative Example 49	Color filter (III)	Comparative Example 36	Comparative Example 35	Comparative Example 34
Comparative Example 50	Color filter (III)	Comparative Example 39	Comparative Example 38	Comparative Example 37
Comparative Example 51	Color filter (III)	Comparative Example 42	Comparative Example 41	Comparative Example 40
Reference Example 18	Color filter (III)	Reference Example 15	Reference Example 14	Reference Example 13

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Table 32 (continued)

Comparative Examples and Reference Examples	Properties of color filter			
	Transmittance			Contrast (%)
	(R) (620 nm) (%)	(G) (530 nm) (%)	(B) (460 nm) (%)	
Comparative Example 43	64.3	66.2	66.3	570
Comparative Example 44	61.8	64.9	65.0	460
Comparative Example 45	45.3	47.3	51.6	590
Reference Example 16	83.7	85.9	85.0	740
Comparative Example 46	64.8	66.9	66.5	520
Comparative Example 47	62.2	64.3	64.8	480
Comparative Example 48	45.3	51.3	52.6	520
Reference Example 17	84.3	86.2	85.2	790
Comparative Example 49	64.7	68.3	67.2	680
Comparative Example 50	62.5	65.6	66.8	560
Comparative Example 51	44.2	46.6	50.3	460
Reference Example 18	83.5	86.1	85.1	780